CFI LESSON PLANS

THE BACKSEAT PILOT

TERMS AND CONDITIONS

USING THE CFI CONTENT

EBOOK NAVIGATION (immensely helpful)

- Word: **Open the View Tab & check Navigation Pane in the box labeled 'Show'**
- Adobe: Open the Bookmarks bar

ACS KNOWLEDGE & RISK MANAGEMENT ELEMENTS

- Every single task is annotated (Ex: AI.II.G.K1, AI.VII.N.R2). Search for anything you need

RISK MANAGEMENT CONTENT

- Many sections contain numerous repetitive risk management elements
- Rather than repeating the information over and over, you'll find the RM concepts at the end of the applicable section (VII – XII)
- In the eBooks, the lessons that reference these topics are linked to the RM section

IMPORTING THE PDF TO AN IPAD

- Login to your account, tap the My Digital Content button, open the PDF & tap the screen
- In the box that appears at the bottom center of the screen, tap Download
- When the download is complete, tap Open In and choose the desired app
- ForeFlight provides multiple different ways to import a document

LEGEND / ABBREVIATIONS

- * - The lessons were originally based on the DA20. Remaining DA20 info is shown by a *
- RM: ACS Risk Management concept
- CE: Common Error

QUESTIONS OR ISSUES

- info@thebackseatpilot.com – More than happy to help!

RECENT UPDATES

Most of the recent updates are indicated with a Red bar in the left margin (not shown in the PDF)
To View/Remove the Red Bar in Word, select the Review tab, Track Changes drop down, then Track Changes

DATE	LESSON(S)	CHANGES
Aug 2024	Numerous Lessons	Very minor updates to streamline RM content
July 2024	All Lessons Sections VI-XII	Added ACS annotations for all Knowledge & Risk Management tasks Updated to include the latest AFH Common Errors & moved Common Errors into the lesson plan (ACS required task now)
May 2024	All Lessons	Various updates to clean up/expand on RM concepts Various updates to match the ACS updated PowerPoints
April 2024	All Lessons	Updated to the new Instructor ACS standards

CONTENTS

FUNDAMENTALS OF INSTRUCTING

I.A. Effects of Behavior & Communication on the Learning Process

References: Aviation Instructor's Handbook (FAA-H-8083-9) Chapters 2 & 4

Objectives	The learner should develop knowledge of the elements related to human behavior and effective communication as required in the Instructor ACS.
Elements	1. Elements of Human Behavior 2. Learner Emotional Reactions 3. Teaching the Adult Learner 4. Effective Communication 5. Recognizing & Accommodating Human Behavior
Schedule	1. Discuss Objectives 2. Review Material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner will understand the 3 basic elements of the communicative process, recognize the various barriers to communication, and develop communication skills to convey the desired information to future learners.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Years of thinking people have understood you. Unless you've known this stuff, they haven't.

Overview

Review Objectives and Elements/Key ideas

What

How human behavior (needs, personalities, motivations, emotions, age, communication, etc.) affect the learning process.

Why

Learning is a change of behavior as a result of experience. To successfully accomplish the task of helping bring about this change, the instructor must know why people act the way they do.

How:

1. **Elements of Human Behavior** (Aviation Instructor's Handbook, Chapter 2) FI.I.A.K1
   - A. Definitions of Human Behavior FI.I.A.K1a
     - i. The study of human behavior is an attempt to explain how & why human functions the way they do
       - a. Combination of innate human nature and individual experience & environment
       - b. Working knowledge of behavior can help an instructor better understand a student
     - ii. Scientific World Definition
       - a. Behavior is the product of factors that cause people to act in predictable ways
         - Ex: Fear (Aviation Instructor's Handbook uses public speaking example)
           - a Fear triggers innate biological responses in everyone (increased breathing, etc.)
           - b How a person handles the fear is a product of individual experiences
             1. Not being able to speak publicly, versus taking public speaking classes
     - iii. Satisfying Needs Definition
       - a. Human behavior is the result of attempts to satisfy certain needs
         - Simple needs drive behavior: food, water
         - Complex needs also drive behavior: respect and acceptance
       - b. To a large extent, thoughts, feelings and behavior are shared by all men and women
     - iv. Life Course of Humans Definition
       - a. As humans grow, behavior changes
         - As people mature, their mode of actions moves from dependency to self-direction
         - Therefore, the age of the learner impacts how curriculum design
     - v. Personality Types
       - a. Myers Briggs Type Indicator
         - Seemingly random variation in behavior is quite structured and is due to differences in the ways individuals prefer to use their perception & judgment
         - Myers-Briggs distilled behavior into 16 personality types
           - a Others have contributed to and continued personality research
           - b Various tests developed with uses from career choices to marriage partners
       - b. Personality Tests

- Provide your personality type based on their personality types
  - a Your priorities, strengths, weaknesses, motivators, stressors, how you react to others
- Other personalities and how to effectively connect with them
- Example: DiSC Assessment (not free, but can see a bit of a sample report)

c. Big Picture: People learn, respond, and relate in different ways based on their personalities
- What works for one person may not work for another
- The more you know about behavior and the individual, the better you can instruct

B. Instructor and Learner Relationship FI.I.A.K1b

i. Personality affects how one learns & teaches

ii. Instructor must understand their style of teaching and as much as possible adapt to learners

a. Adjust teaching style & scenarios to fit learner's learning style

C. Motivation FI.I.A.K1c

i. The reason one acts or behaves in a certain way and lies at the heart of goals

a. Motivation prompts people to put forth effort and affects student success/goals

b. Probably the dominant force governing student's progress and ability to learn
- Important to discover what motivates each student to encourage hard work
- Determining why they are enrolled in the course can provide insight into motivations

ii. Positive Motivation

a. Promise or achievement of awards (personal, social, financial, satisfaction of self, recognition)

b. Essential to true learning & more effective than negative motivation

c. Examples of Positive Motivations
- Secure, pleasant conditions and a safe environment
- Tangible return for efforts
  - a Lesson objectives should be clear and explain the benefit of concepts/training
- Group approval/belonging
- Favorable self-image (increasing self-confidence and abilities)

iii. Maintaining Motivation

a. Reward Success
- Praise incremental successes during training
- Relate accomplishments to lesson objectives
- Comment favorably on progress and ability

b. Present New Challenges
- With each success, present the next challenge

iv. Drops in Motivation

a. Natural, especially after the initial excitement wears off

b. Remind students of their goals and reasons for training

c. Ensure students know that learning plateaus are normal

D. Human Needs FI.I.A.K1d

i. Hierarchy of Human Needs – An organization of human needs into levels of importance

a. Until the needs are satisfied, one can't focus fully on learning, self-expression, or any other task
- Once a need is satisfied, it no longer provides motivation
  - a Thus, the person strives to satisfy the needs of the next higher level

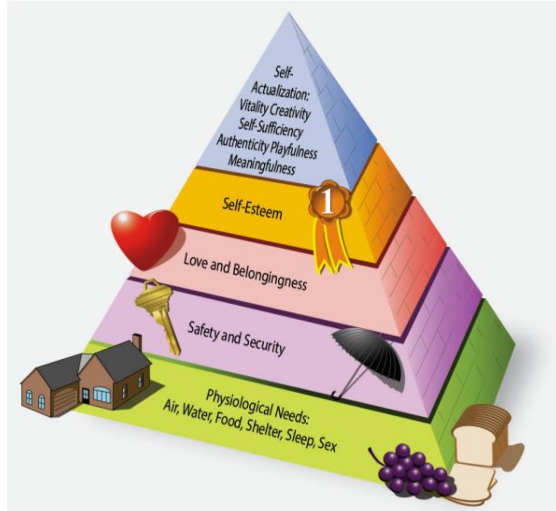
ii. **Physiological**

a. Biological needs: Food, rest, and protection from the elements

iii. **Security**

a. Protection against danger, threats, deprivation affect learner behavior

b. If a learner does not feel safe, he or she cannot concentrate fully on learning, self-expression or any



other task

iv. **Belonging**
  a. Belong, to associate, and to give and receive friendship and love
    - Learners are usually out of their normal surroundings so this need will be more pronounced
  b. Ensure new learners feel at ease and their decision to pursue aviation is reinforced

v. **Esteem**
  a. Needs consist of two types:
    - Internally - Relating to self-esteem: confidence, independence, achievement, competence, knowledge
    - Externally - Relating to reputation: status, recognition, appreciation, and respect of associates
  b. This may be the main reason for the learner's interest in aviation

vi. **Cognitive and Aesthetic**
  a. This need was added years after initial development of the theory
  b. Cognitive: Need to know and understand
    - If a person understands what is going on, they can either control the situation or make informed decisions about what steps might be taken next
  c. Aesthetic: Connect directly with emotions
    - Subtle factor in the domain of persuasion
    - When someone likes something, the reasons are not examined – they simply like it
      a But, if an instructor does not like a learner, this subtle feeling may affect the ability to teach

vii. **Self-Actualization**
  a. A person's need to be and do what one was "born to do"
  b. When all other needs are satisfied only then can self-actualization be attained
  c. Realizing one's own potential for continued development/Reaching personal goals & potential

viii. Help learners satisfy their needs in a manner that will create a healthy learning environment

E. Defense Mechanisms FI.I.A.K1e

i. Subconscious, almost automatic, ego-protecting reactions to unpleasant situations
  a. Used to soften feelings of failure, to alleviate feelings of guilt, and to protect personal worth

ii. **Repression**
  a. A person places uncomfortable thoughts into inaccessible areas of the unconscious mind. Things a person is unable to cope with now are pushed away, to be dealt with at another time, or hopefully never because they fade away on their own accord

iii. **Denial**
  a. Refusal to accept a reality because it is too threatening

iv. **Compensation**
  a. Learners attempt to disguise the presence of a weak quality by emphasizing a more positive one
    - "I'm not a fighter, I'm a lover" philosophy can be an example of compensation
  b. May accept and develop a less preferred but more attainable objective instead of a more preferred but less attainable objective

v. **Projection**
  a. Blame is relegated to others for their own shortcomings, mistakes, and transgressions

b. Motives, desires, characteristics, and impulses are attributed to others
c. "I failed because I had a poor examiner" – the learner believes the failure was not their fault

vi. **Rationalization**
a. Subconscious technique for justifying actions that otherwise would be unacceptable
b. When true rationalization takes place, individuals sincerely believe in their excuses
c. For example, failing a test because "there was not enough time to study," when the learner skipped study groups and practice tests

vii. **Reaction Formation**
a. Sometimes individuals protect themselves from dangerous desires by not only repressing them, but actually developing conscious attitudes and behavior patterns that are just the opposite

viii. **Fantasy**
a. Daydreaming about how things should be rather than doing something about how they are

ix. **Displacement**
a. Unconscious shift of emotion, affect, or desire from the original object to a more acceptable, less threatening substitute

2. Learner Emotional Reactions (Aviation Instructor's Handbook, Chapter 2) FI.I.A.K2

A. Anxiety – "A state of mental uneasiness arising from fear…" FI.I.A.K2a
i. Most significant psychological factor affecting flight instruction
ii. Anxiety can be countered by reinforcing enjoyment of flying, and by teaching to cope with fear
a. Treat fears as a normal reaction, do not ignore them
iii. Introduce maneuvers with care so the learner knows what to expect/what their reaction should be

B. Impatience FI.I.A.K2b
i. An impatient learner fails to understand the need for preliminary training and seeks only the ultimate objective without considering the means to reach it
ii. Counter impatience by presenting the necessary preliminary training one step at a time, with clearly state goals for each step, while tailing instruction to the pace of the learner (i.e. slow learner vs motivated, fast learner)

C. Worry or Lack of Interest FI.I.A.K2c
i. Learners who are worried or emotionally upset are not ready to learn and gain little from instruction
a. Outside experiences affect behavior and performance in training – the instructor is not responsible for these diversions, but also cannot ignore them because they affect learning
ii. Instruction should be keyed to divert attention from their worries and troubles to the tasks at hand
iii. The most effective cure is prevention – ensure the learner knows at the end of each lesson exactly how well they have progressed and what deficiencies are present

D. Physical Discomfort, Illness, Fatigue, and Dehydration FI.I.A.K2d
i. All these conditions slow the rate of learning, and should be mitigated to the extent possible
ii. Fatigue – one of the most treacherous hazards to flight safety
a. Acute Fatigue: Normal occurrence of everyday living
b. Chronic Fatigue: Combination of both physiological problems and psychological issues (financial, home life, job-related stress)
c. Fatigue impairs and adversely affects pilot judgement and decision making
d. Be aware of fatigue and adjust the length and frequency of training as necessary
iii. Dehydration and Heatstroke
a. Dehydration: Critical loss of water to the body. Reduces alertness
b. Heatstroke: Inability of the body to control its temperature
c. Carry ample water on any long flight, keep the temperature cool, and wear light clothing

E. Apathy Due to Inadequate Instruction FI.I.A.K2e
i. To hold interest and maintain motivation, provide well-planned, appropriate & accurate instruction

- ii. Instruction should be meaningful
  - a. Teach to the level of the learner. Be professional (appearance and presentation of material)
- iii. Once the instructor loses confidence, it is difficult to regain, and learning is diminished

F. Stress FI.I.A.K2a

- i. Normal Reactions to Stress
  - a. Respond rapidly and exactly, within the limits of their experience and training
    - This is desired, stress should not overwhelm and cause abnormal reactions (below)
- ii. Abnormal Reactions to Stress
  - a. Response may be completely absent or at least inadequate
  - b. Response may be random or illogical, or they may do more than is called for by the situation
  - c. Abnormal Reactions:
    - Inappropriate reaction, such as extreme over-cooperation, painstaking self-control, inappropriate laughter or singing, and very rapid changes in emotion
    - Marked changes in mood on different lessons (excellent morale/deep depression)
    - Severe anger to the instructor, service personnel, and others
- iii. Seriously Abnormal Learners
  - a. Refrain from instructing the learner and assure they don't continue training/become certificated
    - Have another instructor (not acquainted with the learner) conduct an evaluation flight
      - a Confer to determine whether further investigation or action is justified
    - Primary legal responsibility is whether to endorse the learner to for solo or a practical test
      - a If the student may have a serious psychological deficiency, don't endorse/recommend

3. Teaching the Adult Learner (Aviation Instructor's Handbook, Chapter 2) FI.I.A.K3

A. Certain traits need to be recognized when teaching adults

- i. Adult Learner Characteristics
  - a. Learning is a means to an end (generally have a use for the knowledge/skill)
  - b. Seek out learning experiences to cope with specific life changing events (marriage, new job, etc.)
  - c. Autonomous & self-directed; need to be independent & exercise control
  - d. Draw from foundation of life experience and knowledge for learning
  - e. Goal oriented
  - f. Relevancy oriented
  - g. Practical, focusing on aspects of a lesson most useful to them in their work
  - h. Need to be shown respect
  - i. Need to increase or maintain a sense of self-esteem is a strong secondary motivator
  - j. Want to solve problems & apply new knowledge immediately
- ii. Instructors Should
  - a. Provide an organized training syllabus with clearly defined objectives
  - b. Help students integrate new ideas with what they already know
  - c. Clarify and articulate student expectations early
  - d. Recognize the student's need to control pace and start/stop time
  - e. Use scenario-based training (takes advantage of preference to self-direct)
  - f. Provide self-directed learning involving other people as resources, guides, etc. (don't isolate)
  - g. Use books, programmed instruction and computers which are popular with adults
  - h. Refrain from "spoon-feeding"
  - i. Set a cooperative learning climate
  - j. Create opportunities for mutual planning

4. Effective Communication (Aviation Instructor's Handbook, Chapter 4) FI.I.A.K4

A. A style of communication must be developed that can convey info to learners

B. Basic Elements of Communication FI.I.A.K4a
  i. Communication takes place when a person transmits ideas/feelings to another
  ii. Effectiveness is measured by the similarity between the idea transmitted and the idea received
    a. Receiver reacts with understanding and changes their behavior accordingly
    b. A change in behavior is the goal of communication
  iii. 3 elements of communication: Source, Symbols, Receiver
    a. **Source** (the sender, speaker, transmitter, or instructor)
      - Effectiveness as a communicator is related to 3 basic factors
        a An ability to select and use language is essential for transmitting meaningful symbols
          1. Effectiveness is dependent on the understanding of the words used
          2. Basically, the words you use are important to learning
        b Communicators reveal information about themselves – self-image, views of ideas being communicated as well as the receiver
          1. Basically, have a positive attitude!
        c Material is accurate, up-to-date, and stimulating
          1. Out of date info makes you look bad, and you lose credibility
        d In summary, as the instructor speak clearly and professionally, using words the learners can understand; be positive, and know the information you're teaching
    b. **Symbols** (words or signs, or simple oral, visual, or tactile codes)
      - Determine the symbols best to start/end & those best for explaining, clarifying, emphasizing
        a Then determine which medium is best suited for transmission (hearing, seeing, touch)
      - Monitor the feedback from a learner as symbols may need to be modified for clarity
      - Learners need feedback on how they are doing (Negative feedback in private only)
    c. **Receiver** (the listener, reader, or learner)
      - Effective communication: Receiver reacts with understanding & changes behavior
      - To change behavior, the learner's abilities, attitudes, experiences need to be understood
        a Learners come with a wide variety of abilities, tailor instruction to their level
        b Age, gender, cultural background, education, etc. can influence behavior
        c A varied communicative approach will succeed best in reaching most learners
          1. Not all learners learn in the same way, using multiple approaches is most effective
        d Experience, background, and ability will help determine the instructor's approach

C. RM: Barriers to Effective Communication FI.I.A.K4b, FI.I.A.R.2
  i. Lack of Common Experience
    a. Greatest single barrier to effective communication
    b. A communicator's words cannot communicate the desired meaning to another person unless he has had some experience with the objects or concepts to which these words refer
      - It is essential that instructors speak the same language as the learners
      - If specific terminology is needed, ensure understanding (especially common in aviation)
  ii. Confusion Between the Symbol and the Symbolized Object
    a. This results when a word is confused with what it is meant to represent
      - Words and symbols do not always represent the same thing to every person
      - Make sure associations are clear
    b. For communication to be effective, the learner's understanding must match the instructor's
  iii. Overuse of Abstractions (words that are general rather than specific)
    a. Abstractions do not evoke the same items of experience in the minds of learners
      - Avoid abstractions in most cases
  iv. External Factors

a. Factors outside the instructor's control preventing an activity from being carried out properly
b. Physiological interference is any physical problem that may inhibit understanding
    - Hearing loss, injury, physical illness, etc.
c. Environmental interference is caused by external physical conditions (like noise)
d. Psychological interference is a product of how the learner/instructor feel
    - If either isn't committed, or if fear or mistrust exist then communication is impaired
e. Consider the effects of these factors and mitigate them where possible

v. Interference
    a. Occurs when the message gets disrupted, truncated, or added to
        - Instructor/learner believe an intact message was sent/received when it wasn't
    b. Additional feedback and confirmation reduce the harmful effects of interference

D. Developing Communication Skills — FI.I.A.K4c
    i. Role Playing
        a. Practice instructing to develop communication skills, techniques, etc.
        b. For example: Flying with an instructor who plays the role of a learner to assess your teaching
    ii. Instructional Communication
        a. Know the topic well
        b. Do not be afraid to use examples of past experience to illustrate particular points
        c. Determine the level of understanding by some sort of evaluation
            - Ask them questions to gauge their understanding
    iii. Listening
        a. One way to become better acquainted with learners is to be a good listener
        b. Learners also need to want to listen
            - Teaching learners how to listen will improve information transfer
        c. The pilot must be ready to listen and be responsible for listening
        d. Listen to understand, rather than refute
            - If certain areas arouse emotion, be aware of this and take extra measures to listen
                a Emotions can interfere with listening
                b Ex: a strong fear of spins distracting the pilot from listening to a lesson about spins
        e. Listen for the main ideas
        f. Don't daydream
        g. Take notes (no one can remember everything)
    iv. Questioning
        a. Good questioning can determine how well a learner understands
        b. Ask open ended and focused questions
            - Open ended questions allow the learner to explain more fully
                a Explaining (or teaching) the lesson to you (the instructor) helps the learner learn
            - Focused questions allow the instructor to concentrate on desired areas
                a Focused questions are good to measure general knowledge of a subject
        c. Paraphrasing and perception checking can confirm understanding is in the same way
            - Perception checking gets into feelings by stating the instructor's perceptions of the learner's behavior and the learner can clarify them as necessary
    v. Instructional Enhancement
        a. The deeper the knowledge about an area, the better the instructor is at conveying it

5. RM: **Recognizing & Accommodating Human Behavior** — FI.I.A.R1

A. Working knowledge of behavior can help an instructor better understand a student
    i. Leads to successful instruction

B. Understand and adjust for different personalities, motivators, ages, learning styles, etc.

Conclusion:
Brief review of the main points
An awareness of the 3 basic elements indicates the beginning of the understanding required for the successful communicator. Recognizing the various barriers to communication further enhances the flow of ideas. The instructor must develop communication skills to convey desired info to learners and recognize that communication is a two-way process. The true test of whether successful communication has taken place is to determine if the desired results have been achieved and the learner's behavior has been changed.

I.B. Learning Process

References: Aviation Instructor's Handbook (FAA-H-8083-9) – Chapter 3

Objectives	The learner should develop knowledge of the elements related to the learning process as required in the Instructor ACS.
Elements	1. Definitions of Learning 2. Learning Theory 3. Perceptions and Insight 4. Acquiring Knowledge 5. Laws of Learning 6. Domains of Learning 7. Characteristics of Learning 8. Acquiring Skill Knowledge 9. Distractions & Interruptions, Fixation & Inattention 10. Errors 11. Memory & Forgetting 12. Retention of Learning 13. Transfer of Learning 14. Risk Management Concepts
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the learning process and can integrate the knowledge when instructing learners.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story
This will explain why you will or will not remember this lesson.

Overview

Review Objectives and Elements/Key ideas

What

Understanding how people learn and applying that knowledge to the learning environment.

Why

As a flight instructor, the ability to effectively teach learners is imperative. Understanding how people learn and how to apply that knowledge is the basis for effective teaching.

How:

1. **Definitions of Learning** FI.I.B.K1
   A. Numerous definitions
      i. Change in behavior of the learner as a result of experience
         a. Behavior can be physical and overt, or it can be intellectual or attitudinal
      ii. Process by which experience brings about a relatively permanent change in behavior
      iii. Change in behavior that results from expertise & practice
      iv. Gaining knowledge or skills, or developing a behavior, through study, instruction, or expertise
      v. Process of acquiring knowledge or skill through study, expertise, or teaching
         a. Depends on experience and leads to long-term changes in behavior potential
         b. Behavior potential: Possible behavior of an individual in a given situation in order to achieve a goal
      vi. Relatively permanent change in cognition, resulting from experience and directly influencing behavior
   B. Effective instructors
      i. Understand the subject material, the learner, and the learning process & the relationship between them
      ii. Realize learning is a complex process
      iii. Assist each learner in reaching their goals while building self-esteem & confidence
2. **Learning Theory** FI.I.B.K2
   A. Definition – A body of principles used to explain how people acquire skills, knowledge, and attitudes
   B. How people learn is explained by 2 basic concepts: Behaviorism and Cognitive Theory
   C. Behaviorism (Positive Reinforcement, rather than no reinforcement or punishment) FI.I.B.K2a
      i. Stresses the importance of having particular behavior reinforced, to shape or control what is learned
         a. The instructor provides the reinforcement
      ii. Frequent positive reinforcement and rewards accelerate learning
      iii. The theory provides ways to encourage the learner's progress and learning with rewards
      iv. Today, behaviorism is used more to break unwanted behaviors, such as smoking, than in teaching
         a. The popularity of behaviorism has waned – learning has been shown to be a much more complex process than a response to a stimuli
   D. Cognitive Theory (Focuses on what is going on inside the learner's mind) FI.I.B.K2b
      i. Learning isn't just a change in behavior; it is a change in the way a learner thinks/understands/feels
      ii. Two Major Branches of the Cognitive Theory
         a. The Information Processing Theory

- The learner's brain has internal structures which select and process incoming material, store/retrieve it, use it to produce behavior, and receive/process feedback on the results
  - a This involves a number of cognitive processes: gathering and representing information (encoding), retaining of information, and retrieving the information when needed
  - b The brain gets input from the senses; amount of sensory input the brain receives per second is very high, so it lets many of the habitual and routine things go unnoticed
    1. The human unconscious takes charge, leaving the conscious thought processes free
    2. Ex: A pilot using rudder when entering a turn is often unaware of pressing the pedal

b. Constructivism
- Learning is the result of the learner matching new information against preexisting information and integrating it into meaningful connections
  - a Humans construct a unique mental image by combining preexisting information with the information received from sense organs
- High Order Thinking Skills (HOTS) - also referred to as aeronautical decision making (ADM)
  - a Training based on problems or scenarios
    1. Allows for the construction of meaning from experience
  - b Common thread in aviation accidents is the absence of higher order thinking skills
  - c Teaching HOTS
    1. Taught like other cognitive skills: from simple to complex & concrete to abstract
    2. Effective teaching engages the learner in mental activity, has them examine the problem and select the best solution, and explore other ways to accomplish the task
    3. Strategies & methods include:
       a. Problem-based learning instruction
       b. Authentic, real-world problems
       c. Learner-centered learning
       d. Active learning
       e. Cooperative learning
       f. Customized instruction to meet the individual learner's needs
    4. HOTS must be emphasized throughout a program of study for best results
  - d Scenario-Based Training (SBT) FI.I.B.K8
    1. The heart of HOTS, and an example of Problem Based Learning
    2. Uses a structured script of "real world" scenarios to address flight-training objectives in an operational environment
       a. Adapt scenarios to the aircraft, its flight characteristics, and the environment, and require the learner make real-time decisions in a realistic setting
       b. Good Scenario:
          i. Clear set of objectives
          ii. Tailored to the needs of the learner
          iii. Capitalizes on the nuances of the local environment
    3. Offer solutions, evaluate them, choose one, judge effectiveness, reflect on process
    4. The goal is reached when the learner "makes meaning" of the information based on past experience and personal interpretation
    5. After a couple flights, the scenario should be planned/led by the learner

E. Behavioral + Cognitive
   i. Plan, manage, and conduct aviation training with the best features of each theory
   ii. Provides a way to measure the behavioral outcomes and promote cognitive learning

3. Perceptions & Insight FI.I.B.K3

A. Initially, all learning comes from perceptions which come from the senses

- i. New learners are overwhelmed by stimuli and often focus on meaningless things, missing key info
  - a. Instructor needs to direct trainee's perceptions, so the learner obtains relevant information
- B. Factors Affecting Perceptions
  - i. Physical Organism
    - a. Provides the perceptual apparatus (the body) for sensing the world around them
  - ii. Goals and Values
    - a. Every experience is affected by the individual's values and beliefs
      - Understand the learner's values and tailor teaching to those values
    - b. Goals are more highly valued and therefore sought after than other less important ideas
  - iii. Self-Concept
    - a. Self-image (confident or insecure) has a great influence on perception
      - A positive self-image allows the learner to remain open to new experiences
      - A negative self-image has a negative effect on learning
  - iv. Time and Opportunity
    - a. Proper sequence and time are necessary for learning
  - v. Element of Threat
    - a. Does not promote effective learning
      - Attention is limited to threatening object/idea
- C. Insight
  - i. Grouping of perceptions into meaningful wholes
  - ii. 'Aha!' moment when the info 'clicks' and you gain a more complete understanding of the concept
    - a. Learning becomes more meaningful and more permanent
  - iii. One of the instructor's primary responsibilities
  - iv. Help the learner understand how each piece of information relates to the others

4. Acquiring Knowledge FI.I.B.K4

- A. Memorization (first attempt to acquire knowledge)
  - i. Not good for problem solving
- B. Understanding (stage 2 of acquiring knowledge)
  - i. Knowledge is organized in useful ways and a group of memorized facts gives way to understanding
  - ii. Advantages
    - a. Not limited to questions matching memorized facts
    - b. Easier time mastering variations of a process
    - c. Allows for more efficient communication
    - d. Learners who understand the purpose behind a procedure are better able to remember it
- C. Concept Learning
  - i. Based on the assumption that humans tend to group objects, events, ideas, people, etc., that share one or more major attributes that set them apart
    - a. Ex. Military vs civilian aircraft
    - b. By grouping information into concepts, we create manageable categories
  - ii. Enhances understanding when individuals formulate concepts from facts or steps
    - a. Generalized concepts are more powerful than facts because instead of describing one thing, they describe many things at once
    - b. Concepts are revised as knowledge and experience is gained
      - Military aircraft are then revised into heavies and fighters
        - a Heavies are then revised to C130s, C17s and C5s, etc.
  - iii. Schemas
    - a. Cognitive framework that helps people organize and interpret information
    - b. We form schemas when we notice recurring patterns in things frequently observed or done

      - Ex. ATC clearances (IFR clearance, approach clearance, etc.)
    - c. We continuously learn new schemas and revise old ones to accommodate new information
    - d. Disadvantage: Difficult to retain new info that doesn't conform to established schemas

5. Laws of Learning (REEPIR) FI.I.B.K5

- A. Laws of learning provide additional insight into what makes people learn most effectively
- B. **R**eadiness
  - i. The basic needs of the learner need to be met before they're ready or capable of learning
    - a. The instructor can do little to motivate the learner if these needs haven't been met
    - b. If outside responsibilities, interests, worries, etc. weigh heavily, they may have little interest
  - ii. Learners best acquire new knowledge when they see a clear reason for doing so
    - a. Provide useful, applicable, information tailored to a specific learner's experience level
  - iii. Two steps to keep learners in a state of readiness:
    - a. Communicate a clear set of objectives and relate each new topic to the objectives
    - b. Introduce topics in a logical order and leave learners with a need to learn the next topic
  - iv. Be alert to, and capitalize on, teachable moments
    - a. Moments of opportunity when a person is particularly responsive to being taught something
- C. **E**ffect
  - i. Behaviors that lead to satisfying outcomes are likely to be repeated, and vice versa
  - ii. Learning should affect the learner positively and give them a feeling of satisfaction
    - a. Encourage!
    - b. Create situations designed to promote success
  - iii. RM: Lack of learner motivation
- D. **E**xercise
  - i. Connections are strengthened with practice and weakened without it - "Use it or lose it"
  - ii. Exercise is most meaningful/effective when a skill is learned in the context of real-world applications
  - iii. Provide opportunities for practice and ensure it's directed toward a goal and performed properly
- E. **P**rimacy
  - i. What is learned first, often creates a strong, almost unshakable impression
    - a. Un-teaching is much more difficult than teaching
  - ii. The first experience should be positive, functional, and lay the foundation for all that is to follow
- F. **I**ntensity
  - i. A vivid, dramatic, or exciting learning experience teaches more than a routine or boring experience
  - ii. The instructor should use imagination in approaching reality as closely as possible
    - a. Instructional aides can improve realism, motivate learning and challenge learners
- G. **R**ecency
  - i. Things most recently learned are best remembered
    - a. The further removed in time from a new fact/understanding, the more difficult to remember
  - ii. Repeat, restate, or reemphasize important points at the end of a lesson to help in remembering

6. Domains of Learning FI.I.B.K6

- A. What is to be learned: Knowledge, Change in Attitude, Physical Skill, or combo
- B. A framework to help understand the major areas of learning & thinking
- C. **C**ognitive Domain (Knowledge) FI.I.B.K6a
  - i. Includes remembering specific facts and concepts that help develop intellectual abilities & skills
  - ii. 6 major categories, or levels, from the simplest (knowledge) to the most complex (evaluation)

	Competence	Skills Demonstrated	Example
I	Knowledge: remembering information	Define, identify, label, state, list, match, select	1. State the standard temperature at sea level. 2. Define a logbook entry.
II	Comprehension: explaining the meaning of information	Describe, generalize, paraphrase, summarize, estimate, discuss	1. In one sentence explain why aviation uses a standard temperature. 2. Describe why a log entry is required by the FAA.
III	Application: using abstractions in concrete situation	Determine, chart, implement, prepare, solve, use, develop, explain, apply, relate, instruct, show, teaches	1. Using a standard lapse rate, determine what the temperature would be at a pressure altitude of 4000'. 2. Determine when a logbook entry is required.
IV	Analysis: breaking down a whole into component parts	Points out, differentiate distinguish, examine discriminate, compare, outline, prioritize, recognize, subdivide	1. Compare what the different temperatures would be at certain pressure altitudes based on the standard lapse rate. 2. Determine information required for logbook entry.
V	Synthesis: putting parts together to form a new and integrated whole	Create, design, plan, organize, generate, write, adapt, compare, formulate, devise, model, revise, incorporate	1. Generate a chart depicting temperatures for altitudes up to 12,000'. 2. Write a logbook entry for an oil change.
VI	Evaluation: making judgments about the merits of ideas, materials, or phenomena	Appraise, critique, judge, weigh, evaluate, select, compare and contrast, defend, interpret, support	1. Evaluate the importance of this information for a pilot. 2. Evaluate the necessity of keeping logbook entries.

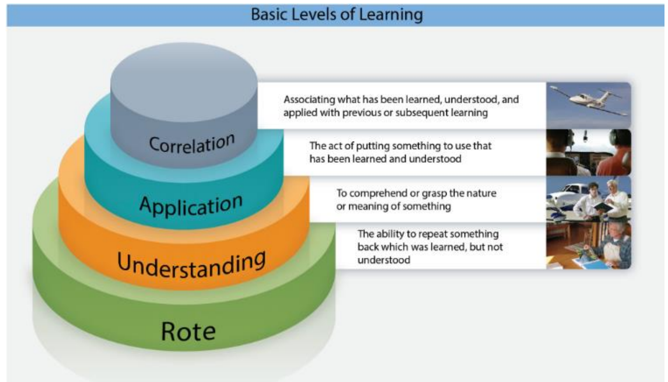
	Objective Level	Action Verbs for Each Level
COGNITIVE DOMAIN	Evaluation	Assess, evaluate, interpret, judge, rate, score, or write
	Synthesis	Compile, compose, design, reconstruct, or formulate
	Analysis	Compare, discriminate, distinguish, or separate
	Application	Compute, demonstrate, employ, operate, or solve
	Comprehension	Convert, explain, locate, report, restate, or select
	Knowledge	Describe, identify, name, point to, recognize, or recall
AFFECTIVE DOMAIN	Characterization	Assess, delegate, practice, influence, revise, and maintain
	Organization	Accept responsibility, adhere, defend, and formulate
	Valuing	Appreciate, follow, join, justify, show concern, or share
	Responding	Conform, greet, help, perform, recite, or write
	Receiving	Ask, choose, give, locate, select, rely, or use
PSYCHOMOTOR DOMAIN	Origination	Combine, compose, construct, design, or originate
	Adaptation	Adapt, alter, change, rearrange, reorganize, or revise
	Complex Overt Response	Same as guided response except more highly coordinated
	Mechanism	Same as guided response except with greater proficiency
	Guided Response	Assemble, build, calibrate, fix, grind, or mend
	Set	Begin, move, react, respond, start, or select
	Perception	Choose, detect, identify, isolate, or compare

D. **Affective Domain** (Attitudes, Beliefs, and Values) FI.I.B.K6b
   i. This hierarchy addresses a learner's emotions toward the educational experience
   ii. Includes feelings, values, enthusiasms, motivations, attitudes
      - Is the learner motivated?
      - RM: Lack of learner motivation
   b. Measuring objectives in this domain is not easy
   c. Ex. evaluating a positive attitude to safety
   iii. Provides a framework for teaching in 5 levels (pictured, right)

E. **Psychomotor Domain** (Physical Skills) FI.I.B.K6c
   i. Skill based and includes physical movement, coordination, and use of the motor-skill areas
      a. Typical activities include learning to fly a precision approach, programming a GPS
   ii. Practical Instructional Levels
      a. Observation
      b. Imitation
      c. Practice
      d. Habit
   iii. As tasks/equipment get more complex, the necessity for integration of cognitive & physical skills increases
   iv. 7 educational objective levels (shown above, right)

F. Four Practical Levels of Learning
   i. Often categorized in the Cognitive Domain
   ii. Rote – Ability to repeat without understanding or application
      a. Define, identify, label
   iii. Understanding – Insight into what has been taught
      a. Learner consolidates old and new perceptions into an insight on a subject/maneuver
      b. Describe, estimate, explain
   iv. Application – Skill for applying what has been learned

Basic Levels of Learning



        a. Understands, has had demonstrations, and has practiced until consistent
        b. Determine, develop, solve
    v. Correlation – Correlation of what has been learned with things previously learned and subsequently encountered
        a. Objective in aviation instruction

7. Characteristics of Learning (PRMA) FI.I.B.K7

A. **P**urposeful
    i. In the process of learning, the learner's goals are the most important factor
        a. Most people have definite ideas about what they want to do and achieve (goals)
        b. Learners learn from any activity that furthers their goals
        c. Individual needs and attitudes may determine what they learn as much as what the instructor is trying to get them to learn
    ii. To be effective, instructors need to find ways to relate new learning to the learner's goals

B. **R**esult of Experience (Learn by Doing)
    i. Learning is an individual process, and the learner can learn only from personal experiences
        a. Previous experiences condition a person to respond to some things and to ignore others
        b. Instructors are faced with the problem of providing learning experiences that are meaningful, varied, and appropriate to individual learners
    ii. If an experience challenges, requires involvement with feelings, thoughts, memory of past experiences, & physical activity, it is far more effective than just committing something to memory
    iii. If learners are to use sound judgment and develop decision making skills, they need learning experiences that involve the use of judgment in solving realistic problems

C. **M**ultifaceted
    i. Individuals learn much more than expected if they fully exercise their minds and feelings
        a. A flight instructor is not just training memory and muscles
        b. The learning process may include verbal elements, conceptual elements, perceptual elements, emotional elements, and problem-solving elements all taking place at once
    ii. While learning the subject at hand, learners may be learning other things as well
        a. They may be developing attitudes about aviation, they may learn self-reliance, etc.

D. **A**ctive Process (Constantly Engage the Learner)
    i. Don't assume a learner remembers something just because they were there when material was presented
    ii. For effective knowledge transfer, learners need to react/respond, perhaps outwardly, perhaps only inwardly, emotionally, or intellectually

8. Acquiring Skill Knowledge FI.I.B.K9

A. Skill knowledge: knowledge reflected in motor or manual skills and in cognitive or mental skills, which manifests itself in the doing of something (Ex. riding a bike)

B. Stages of Acquiring a Skill FI.I.B.K9a
    i. Cognitive Stage
        a. Memorizing the steps to a skill
        b. Provide clear, step by step examples
    ii. Associative Stage
        a. Practice begins to store the skill
        b. The learner can assess progress and make adjustments instead of simply repeating steps
    iii. Automatic Response Stage
        a. Through practice, the skill becomes automatic allowing increased focus on other aspects

C. Knowledge of Results FI.I.B.K9b
    i. The learner must be informed of their progress, both good and bad
        a. Inform as soon after their performance as possible, don't allow learners to practice mistakes

   ii. Flying is foreign; a learner may know something is wrong but may not know how to correct it
D. How to Develop Skills FI.I.B.K9c
   i. Consistent practice improves performance
E. Learning Plateaus FI.I.B.K9d
   i. They're normal and temporary, ensure the learner understands this and is prepared for them
   ii. Over-practice can bring on a learning plateau
      a. If necessary, move away from a certain task and return to it at a later time
F. Types of Practice FI.I.B.K10
   i. Deliberate Practice
      a. Learner practices specific areas for improvement and receives specific feedback after practice
         - Feedback shows differences between performance and desired goal
            a Focus is on eliminating differences
   ii. Blocked Practice
      a. Doing the same task over and over until it becomes automatic
      b. Enhances current (short-term) performance, but does not improve either concept learning or retrieval from long-term memory
   iii. Random Practice
      a. Mixes up the skills to be acquired throughout the practice session
      b. Performing a series of separate skills in a random order leads to better retention
         - Learner starts to recognize the similarities/differences of each skill making it more meaningful
G. Evaluation vs. Critique FI.I.B.K11
   i. Overview
      a. Practical suggestions are more valuable than a grade in the initial stages of skill acquisition
         - Early evaluation provides a check on teaching effectiveness and can help locate problem areas
      b. Instructor monitors learner practice and provides feedback
         - Constructive criticism helps eliminate errors – compliments help keep the evaluation positive
      c. Allowing the learner to critique themselves enhances learner-centered training
   ii. Overlearning of Knowledge
      a. The continued study of a skill after initial proficiency is established
      b. Advantage: Application of knowledge is more streamlined and efficient
      c. Disadvantage:
         - Reduces critical thinking
            a Ex. Checklist recitation that becomes second nature to the point it's decoupled from actions
         - Can impede further learning or lead to forgetting general knowledge
            a Pilots can develop streamlined, automatic procedures tuned to their aircraft/procedures while their overall understanding of the concept diminishes
      d. Remain aware of skills developed as a result of overlearning and ensure learner actions are accompanied by use of their underlying knowledge
   iii. Application of Skill
      a. Final and critical question is "Can the learner use the information received?"
         - Learner needs to understand the skill so well it becomes easy/habitual
         - Learner needs to be able to recognize the situations where the skill is appropriate to use
H. Summary of Instructor's Actions
   i. Explain that the key to acquiring & improving skill is continued practice
   ii. Monitor practice and provide immediate feedback
   iii. Avoid conversation & other distractions when learners are practicing individual skills
   iv. Explain that learning plateaus are common and continued practiced = continued improvement

9. **Distraction, Interruptions, Fixation & Inattention** FI.I.B.K12
    A. Distraction: Unexpected event that causes the learner's attention to be momentarily diverted
        i. Learners need to decide whether a distraction warrants further attention/action
            a. Act on the distraction or turn attention back to what they were doing
    B. Interruption: Unexpected event where the learner voluntarily suspends one task to complete a different one
        i. Significant source of errors
            a. Learners need to develop procedures for dealing with interruptions
            b. Common example, performing a checklist, interrupted, returns to the checklist but at the wrong step
    C. Fixation: Occurs when the learner becomes absorbed in one task to the exclusion of other tasks
        i. Generally, a sign that the task has not been mastered well enough to be performed with other tasks
    D. Inattention: Occurs when a learner fails to pay attention to a task that is important
        i. Can be a natural byproduct of fixation
        ii. Can occur when learners are not busy (bored, or don't find a task important)
        iii. Alert the learner to the problem and develop habits to keep their attention
    E. Identifying Fixation & Inattention Problems
        i. Follow where learners look
            a. Glance at the learner's eyes to see where they are looking
            b. Extended time on one instrument could be fixation
            c. Extended time neglecting engine instruments could be inattention
10. **RM: Errors** (RM: Recognizing and correcting learner errors) FI.I.B.K13, FI.I.B.R3
    A. To believe people can eliminate errors from their performance is to commit the biggest error of all
        i. Be prepared for occasional errors
    B. Two Kind of Errors
        i. Slip
            a. A person plans to do one thing but inadvertently does something else
            b. Forms of Slips
                - Neglect to do something
                - Confuse two similar things
                - Asked to perform a routine in a slightly different way
                - Time pressure
        ii. Mistake
            a. A person plans to do the wrong thing and succeeds
                - Error of thought. Sometimes caused by a gap or misconception in learner's understanding
            b. Forms of Mistakes
                - Incorrect understanding
                - Incorrectly categorizing a specific situation
    C. Reducing Error
        i. Learning and practicing
            a. Chair flying when away from the aircraft can be a huge help (as long as it is practiced properly)
        ii. Taking Time
            a. Work at a comfortable pace
            b. Slow is steady, steady is fast
                - Rushing leads to mistakes and starting over/repeating
        iii. Checking for Errors
            a. Actively look for evidence of errors
        iv. Using Reminders
            a. Checklists, bugs, notebook, etc.

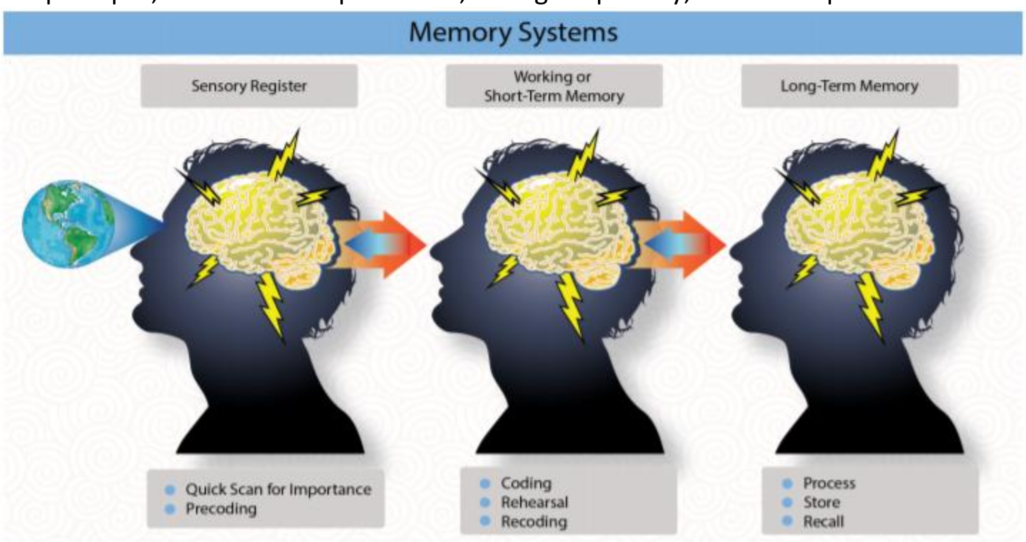
- v. Developing Routines
  - a. Standardized procedures are widely known to reduce errors
- vi. Raising Awareness
  - a. Raise awareness when operating in conditions under which errors are known to happen, or in conditions which defenses against errors have been compromised (fatigue, lack of practice, etc.)

D. Error Recovery
- i. Error is inevitable, learners must learn to recover from situations
  - a. Do not let the error “snowball” and cause additional problems, or grow bigger than it is
    - Solve the problem, and focus on the tasks at hand/ahead

E. Learning from Error
- i. Great learning tool
- ii. When an error is made ask the learner why it happened/what could be done different
- iii. Great debrief topics include a discussion of what went well and what could have gone better

11. Memory & Forgetting FI.I.B.K14

A. Memory General
- i. Memory includes 3 parts: Sensory, Short-Term, and Long-Term Memory
- ii. The total system operates like a computer
  - a. Accepts input, information is processed, storage capability, and an output function



B. Sensory Memory (Quick Scan, Precoding) FI.I.B.K14a
- i. Receives stimuli from the environment and quickly processes it based on a set concept of what is important
  - a. Other factors can influence reception of info
    - If it is dramatic or impacts more than one sense it is more likely to make an impression
- ii. Recognizes certain stimuli and immediately transmits them to short-term memory for action
  - a. Called precoding (ex. Fire Alarm – working memory is immediately made aware of the alarm and preset responses begin to take place)
- iii. Capable of retaining information for only a very short period of time and within seconds the relevant information is passed to the short-term memory

C. Short-Term Memory (Coding, Rehearsal, Recoding) FI.I.B.K14b
- i. Short-term memory resembles the control tower of a major airport and is responsible for coordinating all incoming and outgoing flights
  - a. Information is stored for roughly 30 seconds, after which it may rapidly fade or be consolidated into long-term memory, depending on the individual’s priorities

- ii. Rehearsal or repetition of the info and sorting or categorization into chucks help with retention
  - a. The sorting process is called Coding or Chunking
  - b. Usually takes 5 - 10 sec; if interrupted, the information is easily lost since it is only stored for 30 seconds
- iii. Time limited and Capacity limited (time limitation can be overcome by repetition)
- iv. The coding process may involve recoding to adjust information to individual experiences
  - a. This is when actual learning begins to take place
  - b. Recoding: relating incoming information to concepts or knowledge already in memory
- v. Three basic operations of Short-term memory
  - a. Iconic Memory: Brief sensory memory of visual images
  - b. Acoustic Memory: Encoded memory of a brief sound or the ability to hold sounds in short-term memory
  - c. Working Memory: Active process to keep information until it is put to use
    - The goal of working memory is merely to put the information to use
- vi. Developing a logical strategy for coding information is a significant step in the learning process

D. Long-Term Memory (Process, Store, Recall) FI.I.B.K14b
- i. Relatively permanent storage of unlimited information
  - a. For it to be useful, special effort must have been expended during the coding process
    - The more effective the coding process, the easier the recall
    - What is stored in long-term memory affects a person's perceptions of the world and what information in the environment is noticed
      - a Information that makes it to long-term memory typically has significance attached to it
- ii. One of the major responsibilities of the instructor is to help learners use their memories effectively
  - a. Make training relevant and meaningful enough to transfer information to long-term memory

E. Memory and Usage FI.I.B.K14c
- i. The ability to retrieve knowledge or skills is primarily related to two things:
  - a. How often the knowledge has been used
  - b. How recently the knowledge has been used
- ii. The more frequent and recent knowledge is used, the more likely it is retained

F. Forgetting FI.I.B.K14d
- i. There are many theories regarding why people forget (FIRRS)
  - a. **F**ading: Suggests that information that is not used is forgotten
  - b. **I**nterference: We forget things because an experience has overshadowed it, or the learning of similar things has intervened
    - Two conclusions from interference:
      - a Similar material seems to interfere with memory more than dissimilar material
      - b Material not well learned suffers most from interference
  - c. **R**etrieval Failure: Inability to retrieve the information
  - d. **R**epression or **S**uppression: A memory is pushed out because of the feelings associated with it

12. Retention of Learning FI.I.B.K15

A. The instructor needs to make certain that the learner's learning is readily available for recall
- i. Teach thoroughly and with meaning

B. Praise Stimulates Remembering
- i. Responses that give a pleasurable return tend to be repeated

C. Recall is Promoted by Association
- i. Each bit of information which is associated with something to be learned tends to facilitate its recall

D. RM: Favorable Attitudes Aid Retention (lack of learner motivation)
- i. Without motivation there is little chance for recall; most effective motivation is based on positive objectives

E. Learning with all our Senses is most Effective
- i. When several senses respond together, a fuller understanding/greater chance of recall is achieved

F. Meaningful Repetition Aids Recall (mere repetition does not guarantee retention)
   i. Each repetition provides an opportunity to gain a clearer perception of the subject to be learned
   ii. 3-4 repetitions provide the maximum effect
G. Mnemonics
   i. Pattern of letters, ideas, visual images, or associations to help remember
      a. Include, but not limited to, acronyms, acrostics, rhymes & melody
      b. Ex. ANDS – Accelerate North, Decelerate South

13. Transfer of Learning FI.I.B.K16

A. Primary Objective is to promote Positive Transfer
   i. Positive Transfer - Learning skill A helps to learn skill B (slow flight and short field landings)
   ii. Negative Transfer - Learning skill A hinders learning of skill B (landing an airplane vs a helicopter)
   iii. A degree of transfer is involved in all learning since all learning is based on prior learned experience
   iv. Achieving Positive Transfer
      a. Plan for transfer as a primary objective
      b. Ensure that learners understand that information can be applied in other situations
      c. Maintain high-order learning standards
      d. Avoid unnecessary rote learning, since it does not foster transfer
      e. Provide meaningful learning experiences that build confidence in the ability to transfer knowledge
      f. Use material that helps form valid concepts and generalizations (make relationships clear)
B. Habit Formation
   i. It's the instructor's task to insist on correct techniques/procedures to provide proper habit patterns
   ii. Training traditionally has followed a building block concept
      a. Start with the basics and build from there
C. Understanding
   i. Ability to remember is greatly affected by the level of understanding
   ii. The deeper we think about what we have learned, the more likely we can retrieve the info later
D. Remembering during Training
   i. Threat: Lack of frequent usage in the past
      a. Learner needs to engage in regular practice of what was learned
      b. Shorter, regularly spaced studying produces results far greater than cramming the night before
   ii. Threat: Learner lacks a degree of understanding that may assist with recalling the knowledge
      a. Repetition of knowledge along with efforts to increase understanding leads to best results
      b. Reading with "study questions" (answering and / or creating study questions)
E. Remembering after Training
   i. Continued practice of knowledge and skill is the only means to retaining what was learned
   ii. Practice is as important after certification as it was before
   iii. Skills that become automatic during training may not remain automatic after a period of disuse
F. Sources of Knowledge
   i. Books, photographs, videos, diagrams, charts, etc.
   ii. Encourage the learner to gain experience in the real-world
      a. Continued flying, observation, communication, etc.
G. Summary of Instructor's Actions
   i. Discuss differences between short-term and long-term memory
   ii. Explain the effect of frequent and recent usage of knowledge on remembering and forgetting
   iii. Explain the effect of depth of understanding on remembering and forgetting
   iv. Encourage the learner use of mnemonic devices while studying
   v. Explain the benefits of studying at regularly spaced intervals, and the disadvantages of cramming

14. Risk Management Concepts

A. Lack of Learner Motivation FI.I.B.R2
   i. See lesson I.A. Effects of Behavior & Communication on the Learning Process section 1.C & D
      a. 1.C. Motivation & 1.D. Human Needs
B. Inadequate or Incomplete Instruction FI.I.B.R1
   i. Inadequate preparation or teaching leads to apathy in learners
      a. Nothing destroys a learner's interest as quickly as poorly organized instruction
   ii. Poor instruction also comes from distracting mannerisms, untidiness, or appearing irritated with the learner
   iii. Talking down to the learner is one of the fastest ways to lose their confidence and attention
      a. Once learner confidence is lost, it is difficult to regain, and learning diminishes
   iv. Provide well-planned, appropriate, and accurate instruction
      a. Teach to the level of the learner
      b. Teaching needs to be meaningful to the person for whom it's intended

Conclusion
Brief review of the main points

I.C. Course Development, Lesson Plans, & Classroom Training Techniques

References: Aviation Instructor's Handbook (FAA-H-8083-9) Chapter 3, 5 & 7

Objectives	The learner develops knowledge of the elements related to course & lesson development as required in the Instructor ACS.
Elements	Teaching Course of Training Preparation of a Lesson Organization of Material Training Delivery Methods Electronic Learning Instruction Aids and Training Technologies Problem Based Instruction Integrated Flight Instruction . Planning Instructional Activity
Schedule	Discuss Objectives Review material Development Conclusion
Equipment	White board and markers References
IP's Actions	Discuss lesson objectives Present Lecture Ask and Answer Questions Assign homework
SP's Actions	Participate in discussion Take notes Ask and respond to questions
Completion Standards	The learner understands how to prepare a lesson, and effectively organize and present the material, integrating training aids, problem-based instruction, & other tools based on the specific learner(s) and the situation.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This is how one should structure a lesson to properly ensure the necessary knowledge is retained.

Overview

Review Objectives and Elements/Key ideas

What

The teaching process can be divided into 4 steps - preparation, presentation, application, and review and evaluation. This lesson focuses on the preparation, organization, presentation, and instructional tools and techniques.

Why

Effective planning, organization and presentation is essential to providing a proper learning experience.

How:

1. **Teaching** FI.I.C.K1
   - A. Process FI.I.C.K1a
     - i. Organizes material to teach in a way the learner can understand
     - ii. Four steps: Preparation, Presentation, Application, Review/Evaluation
   - B. 4 Essential Teaching Skills FI.I.C.K1b
     - i. People skills
       - a. Effective instructors relate well to people
       - b. Technical knowledge is useless if it's not communicated effectively
       - c. Effective communication requires actively listening to the learner
     - ii. Subject matter expertise
       - a. Effective instructors have a sincere interesting in learning & professional growth
       - b. Be a lifelong learner, network, continue to develop professionally
     - iii. Management skills
       - a. Ability to plan, organize, lead, and supervise (plan, organize & carry out a lesson)
       - b. Effective time management to achieve goals without over planning
       - c. Supervision of learners when necessary (i.e., preflight procedures)
     - iv. Assessment skills (more details in Task D.)
       - a. Used to verify the learner's progress
       - b. Purpose of the assessment needs to be clear
2. **Course of Training** FI.I.C.K2
   - A. Complete series of studies leading to a specific goal
     - i. Curriculum, syllabus, lesson plan
   - B. Includes
     - i. Curriculum includes courses for various pilot certificates and ratings
     - ii. Syllabus: Summary/outline of an individual course of study containing multiple lessons
       - a. Description of each lesson, including objectives & completion standards
     - iii. Lesson plan: Detailed plan for how a specific lesson is conducted
       - a. Objective, organization of material, teaching aids, instructor/learner actions, evaluation criteria, completion standards
3. **Preparation of a Lesson** FI.I.C.K3

A. A lesson must be planned – Objectives, procedures and facilities, goals to be attained, review/evaluation

B. Training Objectives & Completion Standards FI.I.C.K3a

- i. Training Objectives
  - a. Two types: Performance-based & Decision-based
    - Performance-Based: Define exactly what needs to be done and how it is done
    - As training progresses, shift toward decision-based training objectives
      - a Scenario-based training to teach critical thinking skills (risk management & ADM)
  - b. Clearly defined training objectives that the learner understands are essential
    - Objectives should incorporate the desired level of learning for the applicable domain(s) of learning
      - a Adapt training to a specific performance level of knowledge or skill
- ii. Standards
  - a. Closely tied to objectives
  - b. When a learner performs according to well-defined standards, evidence of learning is apparent
  - c. Standards should contain comprehensive examples of the desired learning outcomes
    - Easier for cognitive & psychomotor domains, more difficult for affective domain
- iii. Incorporating ADM & risk management leads to sound judgement & good decision-making skills

C. Performance Based Objectives FI.I.C.K3b

- i. Set measurable, reasonable standards describing the learner's desired performance
  - a. Objectives must be clear, measurable, and repeatable
- ii. Begin writing a lesson with performance-based objectives (PTS/ACS or syllabus objectives can be used)
- iii. Elements of Performance Based Objectives
  - a. Description of the Skill or Behavior
    - Explains the desired outcome of the instruction as a change in knowledge, skill, or attitude
      - a Should be in concrete and measurable terms
  - b. Conditions
    - Explain the rules for demonstration of the skill
      - a Include information such as equipment, tools, reference material, and limiting parameters
  - c. Criteria
    - Standards that measure objective accomplishment
    - Good criteria leave no question as to whether the performance meets the objective(s)

D. Importance of the ACS FI.I.C.K3c

- i. Supply specific performance objectives based on the standards for issuance of a certificate/rating
  - a. Often reviewed to ensure content & criterion validity
  - b. Content Valid: Maneuvers mimic what is required in actual flying
  - c. Criterion Valid: Completions standards are reflective of acceptable standards (reasonable)
- ii. Use the maneuver-based approach of the ACS but present the objectives as scenario-based training (SBT)
  - a. SBT learners have better decision-making skills compared to solely maneuver-based training

E. Decision-Based Objectives FI.I.C.K3d

- i. Scenario based training develops judgement & ADM skills – facilitates higher level of learning
- ii. Teaches the learner how to gather information and make informed, safe, and timely decisions
- iii. Combined with maneuvers-based training
  - a. Teach maneuvers requiring repitition and once learned, integrate them into realistic flight situations

4. Organization of Material FI.I.C.K4

A. Intro – Sets the stage for everything to come. Consists of 3 elements:

i. Attention – Story, video clip, etc. to direct attention to the lesson
ii. Motivation – Specific reasons why the info is important
iii. Overview – A clear, concise presentation of objectives and key ideas

B. Development – Main body. The material should be organized logically, options include:
i. Past to present
ii. Simple to complex
iii. Known to unknown
iv. Most frequently used to least

C. Conclusion
i. Retraces important elements and relates them to the objective

5. Training Delivery Methods FI.I.C.K5

A. Lecture Method FI.I.C.K5a
i. Suitable for presenting new material, for summarizing ideas, and for showing relationships
ii. Most effective when combined with instructional aids and training devices
iii. Different Types of Lectures:
a. Illustrated Talk – Relies heavily on visual aids to convey ideas
b. Formal Lecture – Purpose is to inform, persuade, or entertain with little learner participation
c. Teaching Lecture – Delivered in a manner that allows some learner participation
- Favored by aviation instructors

iv. Advantages & Disadvantages
a. Convenient to instruct large groups
b. Can be used to present info that would be difficult for learners to get in other ways
c. Supplements other teaching methods & devices
d. Good for providing direction or purpose to a demonstration or providing background information
e. Many ideas can be conveyed in relatively short time
f. Requires a skilled speaker to maintain attention
g. Does not allow a precise measure of learner understanding
h. Does not foster attainment of certain learning outcomes like motor skills

B. Discussion FI.I.C.K5b
i. Uses lecture and then discussion to involve the learner
a. Short lecture followed by instructor-learner & learner-learner discussion
b. Requires participation & develops higher order thinking skills (HOTS)

C. Guided Discussion Method FI.I.C.K5c
i. Goal is to draw out the knowledge of the learner
a. Encourages active participation of the learners
b. The greater the participation, the more effective the learning

ii. The instructor acts as a facilitator – Ask skillful questions (open ended questions encourage more discussion and a better gauge of understanding than specific, use both as necessary)
iii. Helpful in areas where learners can use initiative and imagination in addressing problems

D. Cooperative or Group Learning FI.I.C.K5d
i. Organizes learners into small groups who work together to maximize understanding
a. Leads to better test scores, higher self-esteem, improved social skills & greater comprehension

ii. Instructor
a. Plan what the group is expected to learn and be able to do on their own
b. Use clear & specific objectives to describe the knowledge/abilities to be acquired

iii. Conditions & Controls
a. Small, heterogeneous groups
b. Clear, complete instructions (what to do, in what order, materials)

c. Learner perception of targeted objectives as their own, personal objectives
d. Opportunity for learner success
e. Learner access to and comprehension of required info
f. Sufficient time for learning
g. Individual accountability
h. Recognition & reward for group success
i. Time to reflect on how they worked together as a team

E. Demonstration-Performance Method FI.I.C.K5e
i. Best used for the mastery of mental or physical skills that require practice
ii. Many lessons can combine the lecture and demonstration-performance methods
a. The initial information is given in a classroom with a lecture
b. The information is demonstrated and then applied in the airplane
iii. Five Phases: Explanation, Demonstration, Learner Performance, Instructor Supervision, Evaluation

F. Drill and Practice Method FI.I.C.K5f
i. Connections are strengthened with practice
ii. Learn by practicing and applying what they have been told and shown

G. Be familiar with as many methods as possible

H. RM: Selection of Teaching Method FI.I.C.R1
i. Using the characteristics described, choose the best method(s) based on the situation

6. Electronic Learning FI.I.C.K6

A. General
i. Any type of education involving an electronic component
a. Examples: Flight simulators, computer-based training modules,
ii. Advantages: Time flexible, cost effective, easily updated, accessible from anywhere, self-paced
iii. Limitations: Lack of peer interaction and personal feedback, limited instruction on certain subjects, equipment cost (i.e. simulator), instructor must be sufficiently trained on the system operation, not a replacement for the real thing/real life situations and training

B. Computer Assisted Learning (CAL) Method
i. Couples the computer with multimedia software to create a training device
ii. Reduces manpower
iii. Learners can move at their own pace
iv. Not practical for an entire training program
v. Instructor is responsible for monitoring and oversight of learner progress
a. Computer has no way of knowing when a learner is having difficulty
b. Tends to be more one on one instruction as CAL handles the big picture concepts

C. Simulation, Role-Playing, Video Gaming
i. As gaming grows in popularity, educators are seeking to provide games that help retain subject matter
ii. Flight simulation is most prominent form in aviation training
a. Not perfect for all training, but a great tool
b. Allows the learner to learn/practice in a defined environment
- Can pause, slow down, repeat, change parameters, etc.
c. Can practice things that would otherwise be dangerous in the plane, like emergency procedures

7. Instruction Aids and Training Technologies FI.I.C.K7

A. Effective Instruction Aids FI.I.C.K7a
i. Cover the key points & concepts
ii. Are straightforward & factual making it easy to remember & recall
iii. Are relatively simple

B. Reasons for Instructional Aids FI.I.C.K7b

- i. Assist the instructor in the teaching-learning process
- ii. Clarify relationships between objects and concepts
- iii. Help learners understand & retain knowledge
- iv. Hold their attention
- v. Can utilize multiple senses (help learning)
- vi. Help solve language barriers

C. Guidelines for Use of Instructional Aids FI.I.C.K7c
- i. Process
  - a. Clearly establish the lesson objective
  - b. Gather necessary data
  - c. Organize the material into a lesson plan
  - d. Select the ideas to be supported with aids
    - Concentrate on key points
- ii. Aids should be simple, meaningful to the learner, & compatible with objectives
- iii. Should encourage learner participation

Instructional Aids
Support the lesson objective.
Are learner centered.
Build on previous learning.
Contain useful and meaningful content that is consistent with sound principles of learning.
Appeal to learners.
Maintain learner attention and interest.
Encourage learner participation, when appropriate.
Lead learners in the direction of the behavior or outcomes specified in the learning objective.
Provide proper stimuli and reinforcement.
Contain quality photo, graphs, and text, as required.
Are checked prior to use for completeness and technical accuracy.
Contain appropriate terminology for the learner.
Are properly sequenced.
Are easy to understand.
Include appropriate safety precautions.

D. Types of Aids FI.I.C.K7d
- i. Chalk/Marker Board
- ii. Print Material (media, pictures, drawings, etc.)
- iii. Enhanced Training Materials (training syllabi/records, maneuvers guide, etc.)
- iv. Projected Material (PowerPoint, slides, pictures, etc.)
- v. Video
- vi. Interactive Systems (computer software/apps)
- vii. Computer Assisted Learning (combination of audio, text, graphics, or video on a computer)
- viii. Models, Mockups, Cut-Aways
  - a. Mockup: 3d working model
  - b. Cut-away: Type of model that can be taken apart to reveal inner structure/operation

8. Problem Based Instruction FI.I.C.K9

A. Lessons involving problems encountered in real life which ask learners to find real-world solutions
- i. Starts with a carefully constructed problem to which there is no single solution
- ii. Helps gain a deeper understanding of the information and improves ability to recall the information

B. Effective Problems
- i. Relate to the real world so learners want to solve them
- ii. Require learners to make decisions
- iii. Open ended, not limited to one answer
- iv. Connected to previously learned knowledge and new knowledge
- v. Reflect lesson objectives
- vi. Challenge learners to think critically

C. Teaching HOTS (Higher Order Thinking Skills)
- i. Basic Approach to Teaching HOTS:
  - a. Set up the problem
  - b. Determine learning outcomes for the problem
  - c. Solve the Problem or Task
  - d. Reflect on Problem solving process
  - e. Consider additional solutions through guided discovery
  - f. Reevaluate solution with additional options

g. Reflect on this solution and why it is the best
h. Consider what best means

D. Scenario Based Training
   i. Presents realistic scenarios that allow learners to mentally rehearse and explore practical applications of their knowledge
   ii. Good scenario:
      a. Is not a test
      b. Will not have one right answer
      c. Does not offer an obvious answer
      d. Should not promote errors
      e. Should promote situational awareness and opportunities for decision making
   iii. Consider providing hypothetical emergency situations for the learner to talk through
      a. The Air Force has their student pilots talk through how they would maintain aircraft control, analyze the situation, take the proper action, and land as soon as conditions permit (MATL)
      b. Talking through these steps, one at a time, encourages the pilot to apply the same steps in a real emergency and familiarizes them with many emergency situations
E. Collaborative Problem Solving
   i. Two or more working together to solve a problem
   ii. Instructor assists only when needed
F. Case Study Method
   i. Case Study: Written or oral account of a real-world situation containing a message that educates the learner
   ii. Presents the case for the learner to analyze it, come to conclusions, and offer possible solutions
      a. Effective case studies require the learner to use critical thinking skills
      b. Not necessarily one right answer
   iii. The NTSB is a great place for case studies

9. Integrated Flight Instruction (Aviation Instructor's Handbook, Chapter 9) FI.I.C.K8

A. Learners are taught to perform flight maneuvers both by visual & instrument references
   i. Develops the habit of continually monitoring their own and the aircraft's performance
      a. Leads to improved airspeed control, navigation, coordination, landings, safety, and overall competency
      b. The more accurate the flying, the greater the increase in performance and operating efficiency
B. Procedures
   i. From the beginning, each flight maneuver is introduced using outside and instrument references
   ii. Technique: Some instructors prefer to teach only visual references early in the training, arguing that learners over emphasize the instruments and neglect outside references
      a. Teach visual first, establish a base and habit of looking outside, then integrate with instruments
C. See & Avoid
   i. Ensure the learner develops the habit of looking outside
   ii. Don't allow the focus on instrument indications to preclude scanning & collision avoidance
      a. Most midair collisions occur in daylight, VFR weather conditions

10. Planning Instructional Activity (Aviation Instructor's Handbook, Chapter 7) FI.I.C.K10

A. Blocks of Learning FI.I.C.K10a
   i. Constitute the necessary parts of the total objective

- ii. By developing blocks, a learner can master the segments (blocks) individually
  - a. The blocks can be progressively combined with other segments until reaching the overall objective
  - b. Blocks are more manageable and increase self-confidence versus taking on the overall goal
- iii. Early identification of the foundation of blocks of learning is essential
  - a. They should represent units of learning which can be measured and evaluated
- iv. Blocks should be truly integral - Extraneous blocks are expensive frills, and detract from the final objective
- v. Any learner problems can be divided into blocks of learning to help solve that problem
  - a. Ex. Steep turns can be broken into blocks which can be mastered or fixed to perfect the maneuver

B. Training Syllabus FI.I.C.K10b
- i. Big Picture
  - a. Designed to provide a road map showing how to accomplish the overall objective of a course
  - b. Should be fairly brief but comprehensive enough to cover the essential information
- ii. Format & Content
  - a. The syllabus should always be in the form of an abstract or digest of the course training
    - It should include blocks of learning to be completed in the most efficient order
  - b. Effective training relies on organized blocks of learning
    - Therefore, all syllabi should stress well defined objectives and standards for each lesson
      - a Appropriate objectives/standards should be established for:
        1. The overall course
        2. Each stage of training
        3. The separate flight and ground segments
      - b Other details may be added to explain how to use it / describe pertinent reference materials
- iii. Using a Training Syllabus
  - a. The syllabus must be flexible, and should be used primarily as a guide
    - When necessary, the order of training should be altered to suit progress / special demands
    - Departing from the syllabus, the instructor must consider the effects on the learning blocks
  - b. Ground Lessons
    - Concentrate on the cognitive domain of learning
      - a Many areas concern safety/ADM/judgment which are related to the affective domain
        1. Instructors who can stress these factors along with traditional aviation subjects can favorably influence a learner's attitudes, beliefs, and values
  - c. Flight Lessons
    - Generally, emphasize the psychomotor domain
      - a Affective domain is also important
        1. Attitude toward flight safety, ADM, and judgment should be a major concern
    - Should include risk management instruction
      - a Throughout training include increasingly more subtle risks so the learner becomes more skilled in identifying them
- iv. A syllabus should include special emphasis areas that are causal factors in accidents or incidents
  - a. Ex. Collision and wake turbulence avoidance

C. Lesson Plans FI.I.C.K10c
- i. Purpose
  - a. Designed to assure each learner receives the best possible instruction under existing conditions
    - Help instructors keep a check on their own activity, as well as their learners
    - The instructor has in essence taught the lesson to themselves prior to teaching learners
  - b. An adequate lesson plan, when properly used, should:
    - Assure a wise selection of material and the elimination of unimportant details

- Make certain that due consideration is given to each part of the lesson
- Aid the instructor in presenting the material in a suitable sequence for efficient learning
- Provide an outline for the teaching procedure to be used
- Serve as a means of relating the lesson to the objectives of the course of training
- Give the inexperienced instructor confidence
- Promote uniformity of instruction regardless of the instructor or date on which the less is given

ii. Characteristics
  a. A lesson plan should be a working document that should be revised as changes occur or are needed
  b. Unity – should be a unified segment of instruction
     - No extraneous info not important to the objective
  c. Content – Each lesson should contain new material, but it should be related to previous lessons
  d. Scope – Each lesson should be reasonable in scope
     - Keep the objectives realistic as a person can only master a few principles at a time
  e. Practicality – Plan each lesson in terms of the conditions under which training is to be done
     - Lesson plans in the airplane will differ from those in the classroom
     - Also, the kinds/quantities of instructional aides available have a great influence
  f. Flexibility – A degree of flexibility should be incorporate even though there is an outline
  g. Relation to a Course of Training – Plan and teach each lesson so the relation to objectives is clear
     - EX. A lesson on short field T/O and LDGs should be related to certification and safety objectives
  h. Instructional Steps – Every lesson, when adequately developed, falls logically into the four steps of the teaching process (Preparation, Presentation, Application, Evaluation)

Conclusion

Brief review of the main points

I.D. Student Evaluation, Assessment, & Testing

References: Aviation Instructor's Handbook (FAA-H-8083-9) Chapter 6 & 9

Objectives	The learner should develop knowledge of the elements related to evaluation, assessment & testing as required in the Instructor ACS.
Elements	1. Assessment 2. Critique 3. Assessment of Piloting Ability
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can properly critique and evaluate learners using the methods and characteristics described.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The dreaded tests and awful instructor critiques, this is how you do it.

Overview

Review Objectives and Elements/Key ideas

What

The instructor's role in assessing levels of learning, including the different methods of assessment, and how to conduct effective assessments, critiques, and tests.

Why

The instructor must be able to appraise the learner's performance and convey this information back to the learner to maximize learning and progress. This is not only an essential part of testing, but occurs after every flight, at stage checks, and in preparation for the checkride to measure and document whether course objectives have been met.

How:

1. **Assessment** FI.I.D.K1
   - A. Purpose: To determine how a learner is progressing in the course
     - i. Provides practical and specific feedback to learners, including direction and guidance to raise performance
       - a. Highlights areas where a learner is lacking, helps the instructor see where more help is needed
     - ii. Provides an opportunity for self-evaluation and enhances aeronautical decision making and judgement skills
   - B. Characteristics of an Effective Assessment
     - i. Objective
       - a. Must be honest, and based on the facts of the performance as they were, not as they could have been
     - ii. Flexible
       - a. Performance must be examined in the context it was accomplished
       - b. Fit the tone, technique, and content of the assessment to the occasion, as well as the learner
       - c. Allow for variables
       - d. The ongoing challenge for the instructor is deciding what to say, omit, stress, and minimize
     - iii. Acceptable
       - a. Confidence in the instructor's qualifications, teaching ability, sincerity, competence and authority make an honest assessment acceptable to a learner
         - The instructor's manner, attitude, and familiarity with the subject play into the learner's confidence
       - b. Present the critique fairly, with authority, conviction, sincerity, and from a position of competence
     - iv. Comprehensive
       - a. Cover strengths AND weaknesses
       - b. What will provide the greatest benefit?
         - A few major points or more minor points (tailor to the learner)
         - Critique what needs improved most or only what can be reasonably expected to improve
     - v. Constructive
       - a. An assessment is pointless unless the learner benefits from it
       - b. When identifying a mistake or weakness, give positive guidance for correction
         - Praise for its own sake, or negative comments that don't point to improvement should be omitted

vi. Organized
   a. Needs to follow some pattern of organization otherwise it may lose its impact
      - Any pattern is acceptable if it is logical and makes sense to learner and instructor
   b. Options include:
      - The sequence of the performance itself
      - Work backward from where the demonstration failed (or was successful)
      - Break the whole into parts or build the parts into a whole

vii. Thoughtful
   a. Reflects thoughtfulness toward the learner's need for self-esteem, recognition, and approval
      - Ridicule, anger, or fun at a learner's expense have no place in a critique
   b. While being straightforward and honest, always respect the learner's personal feelings

viii. Specific (rather than general)
   a. Learners cannot act on recommendations unless they know specifically what the recommendations are
      - Tell the learner why something was not good and offer suggestions on how to improve
   b. Learners should have no doubt what was good, and what was poor, and how they can improve

C. Traditional Assessment FI.I.D.K2

i. Generally, refers to written testing, such as multiple choice, matching, fill in the blank, etc.
   a. Measure of performance is limited, and a good grade may not reflect an ability to apply the knowledge

ii. Characteristics of a good test:
   a. Reliability: Degree to which test results are consistent with repeated measurements
   b. Validity: Extent to which a test measures what it is supposed to measure
   c. Usability: Refers to the functionality of the test (legible, clear, easily graded, etc.)
   d. Objectivity: Describes singleness of scoring of the test (i.e., doesn't introduce subjectivity)
   e. Comprehensiveness: Degree to which the test measures the overall objectives
   f. Discrimination: Degree to which a test distinguishes the difference between learners
      - Test designed for discrimination contains:
         a Wide range of scores
         b All levels of difficulty
         c Items that distinguish between learners with differing levels of achievement of the objectives

D. Authentic Assessment FI.I.D.K3

i. Asks a learner to perform real-world tasks and demonstrate a meaningful application of skill/competency
   a. Learners must generate responses from their knowledge rather than choosing from options

ii. Learner-Centered Assessment FI.I.D.K3a
   a. Four-step series of open-ended questions:
      - Replay: verbally replay the flight or procedure
      - Reconstruct: identify the things that could have been done differently
      - Reflect: Reflect on the events to find insight
      - Redirect: Relate the lessons learned to other experiences
   b. Can then compare the instructor's assessment with the learner's self-assessment
   c. Post assessment, progress is recorded on a rubric. Two broad rubrics are used:
      - One that assesses proficiency on skill-focused maneuvers/procedures (Maneuver Grades)
      - One that assesses proficiency on single-pilot resource management (Risk Management Skills)

iii. Maneuver or Procedure Grades FI.I.D.K3b
   a. Describe: Learner can describe characteristics and elements but needs help executing the maneuver
   b. Explain: Learner can describe the activity, its concepts, principles & procedures but needs help executing
   c. Practice: Learner can plan and execute the scenario. Assistance corrects deviation and errors
   d. Perform: Learner identifies/corrects errors & can perform the activity without instructor assistance

e. Not Observed: Not accomplished/required

iv. Assessing Risk Management Skills FI.I.D.K3c

a. Explain: Can identify, describe & understand risks, but needs prompted to identify risks/make decisions

b. Practice: Can identify, understand, and apply SRM principles; assistance corrects deviation & errors

c. Manage-Decide: Can gather the most important data, identify courses of action, evaluate risk in each course of action, and make the appropriate decision; instructor intervention not required

E. Choosing an Effective Assessment Method FI.I.D.K4

i. Determine level-of-learning objectives

a. State individual objectives as general, level-of-learning objectives

- Should measure one of the learning levels of the cognitive, affective, or psychomotor domains

ii. List indicators of desired behaviors

a. Samples of behavior that give the best indication the objective has been achieved

b. Behaviors need to be able to be measured

iii. Establish criterion (performance-based) objectives

a. State the behavior expected, conditions under which it is to be performed, and criteria that must be met

iv. Develop criterion-reference test items

a. Written Test Questions

- Questions should attempt to measure the behavior described in the criterion objectives
- Questions missed identify areas that were not adequately addressed

b. Performance Tests for Maneuvers

- Performance testing is desirable for evaluating training based on ACS/PTS standards
- Instructor's job is to prepare the learner for the practical tests
  - a Evaluate the learner on all tasks before recommending them for the ACS/PTS practical test

F. Oral Assessment FI.I.D.K6

i. Overview

a. Most common means of assessment

b. Questions are generally classified as fact questions (memory or recall) and HOT questions (analyze situations, solve problems, arrive at conclusions)

c. Desirable results when done properly:

- Reveals the effectiveness of the training methods
- Checks learner retention of what has been learned
- Reviews material already presented to the learner
- Can be used to retain learner interest and stimulate thinking
- Emphasizes the important points of training
- Identifies points that need more emphasis
- Checks comprehension of what has been learned
- Promotes active learner participation, which is important to effective learning

ii. Effective Questions FI.I.D.K6a

a. Apply to the subject of instruction

b. Brief and concise, but also clear and definite

c. Adapted to the ability, experience, and stage of training of the learners

d. Center on only one idea (limited to who, what, where, when, why, or how and not a combination)

e. Present a challenge to the learner

iii. Questions to Avoid FI.I.D.K6b

a. Yes / No questions have no place in effective quizzing

- Ex: "Do you understand?" / "Do you have any questions?"

b. Puzzle

c. Oversize
d. Toss-up
e. Bewilderment
f. Trick Questions
g. Irrelevant Questions

iv. Answering Learner Questions FI.I.D.K6c
  a. Be sure you clearly understand the question before attempting to answer
  b. Display an interest in the learner's question and frame an answer that is as direct & accurate as possible
  c. After responding, determine whether the learner is satisfied with the answer
  d. If the question is too complicated or advanced for the current point in training, explain to the learner that it is a good question, but a detailed answer at this time would unnecessarily complicated learning
    - Reintroduce the question later in training
  e. If you cannot answer the question, freely admit not knowing, but promise to get the answer or reintroduce the question later at the appropriate point in training

2. Critique FI.I.D.K5

A. Purpose
  i. An instructor-to-learner assessment
    a. Used in conjunction with a traditional or authentic assessment
  ii. Covers good/bad performance, the individual parts, relationships of individual parts & overall performance

B. Types
  i. Instructor/Learner Critique
    a. The instructor leads a group discussion in which members of a class offer criticism of a performance
      - This should be controlled carefully and directed with a firm purpose (not a free-for-all)
    b. It's often beneficial (if the learner being critiqued approves) to allow other learners to sit in on post-flight debriefs to learn from other's mistakes/successes
  ii. Learner Led Critique
    a. A learner is asked to lead the assessment (instructor can provide structure, if necessary)
    b. This can generate learner interest and learning, and be effective
  iii. Small Group Critique
    a. Small groups are assigned a specific area to analyze and present their findings on
      - The combined reports can result in a comprehensive critique
  iv. Individual Learner Critique by another Learner
    a. Another learner is requested to present the entire assessment
      - The instructor must maintain firm control over the process
  v. Self-Critique
    a. A learner critiques their own personal performance
    b. Do not leave controversial issues unresolved, or erroneous impressions uncorrected
    c. Make sure the learner realizes their mistakes
  vi. Written Critique
    a. 3 advantages:
      - Instructor can devote more time and thought to it
      - Learners can keep written assessments and refer to them whenever they wish
      - The learner has a record of suggestions, recommendations, and opinions of all other learners
    b. Disadvantage is that other members of the class do not benefit

C. Ground Rules
  i. Do not extend the critique beyond its scheduled time limit and into time allotted for other activities
    a. Point of diminishing returns is reached very quickly; no more than 10 – 15 min (Definitely < 30 min)

ii. Avoid trying to cover too much. Get the main points (4-5 things to correct at most)
iii. Allow time for a summary of the critique to reemphasize the most important things to remember
iv. Avoid absolute statements (most rules have exceptions)
v. Avoid controversies with the class and don't take sides
vi. Never allow yourself to be maneuvered into defending criticism
vii. If part of the critique is written, ensure it is consistent with the oral portion

3. **Assessment of Piloting Ability** (Aviation Instructor's Handbook, Chapter 9) FI.I.D.K7
    - A. Overview
        - i. Essential part of the teaching process to determine how, what, and how well learning is occurring
        - ii. Provides learner something constructive to work or build on
        - iii. Provides direction and guidance to raise performance
        - iv. Learner's must understand the purpose of the assessment, otherwise little improvement will result
        - v. Can be used as a tool for reteaching
    - B. Demonstrated Ability
        - i. Assessment must be based on established standards of performance adjusted for the learner's experience
        - ii. Evaluation considers the mastery of maneuver/procedure elements rather than just the overall performance
        - iii. Ex: Qualification of learners for solo & solo xc privileges depends upon demonstrated performance
    - C. Postflight Evaluation
        - i. Keep the learner informed of progress (done along with maneuvers or summarized postflight)
        - ii. Should be written
        - iii. With SBT, collaborative assessment is used when a scenario is completed
            - a. Learner self-assessment (leads to growth in thought process/behaviors) and full instructor assessment
    - D. Solo Flight
        - i. Ensure a positive, confidence building experience
        - ii. Instructor Presence
            - a. Be available to answer questions or resolve issues
            - b. Have access to a portable radio, if possible, to monitor and, terminate the solo if a situation arises
                - Keep communication to a minimum, don't talk on short final
        - iii. Debrief
            - a. Very important to debrief immediately after solo
                - Answer questions, ensure correct flight procedures
    - E. Correction of Errors
        - i. Safety permitting, it's often better to let learners progress part way into a mistake and find a way out
        - ii. Learners may perform a procedure correctly but not fully understand the principles/objectives
            - a. If suspected, require the learner vary the procedure slightly, combine it with another operation, or apply the elements to the performance of another procedure
    - F. Practical Test Recommendations
        - i. Serious flight instructor responsibility
        - ii. Require learner to thoroughly demonstrate the knowledge & skill required for the certificate/rating
            - a. Failure to ensure the learner meets the requirements is a serious deficiency in instructor performance
                - FAA may hold the instructor responsible

RM: Delivering an Assessment FI.I.D.R1

The lesson as a whole is a discussion of mitigating risk associated with delivering assessments

Conclusion

Brief review of the main points

I.E. Elements of Effective Teaching in a Professional Environment

References: Aviation Instructor's Handbook (FAA-H-8083-9) Chapter 8

Objectives	The learner should develop knowledge of the elements related to flight instructor characteristics, responsibilities, & professionalism as necessary in the Instructor ACS.
Elements	1. Aviation Instructor Responsibilities 2. Flight Instructor Responsibilities 3. Qualifications & Professionalism 4. Professional Development
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the responsibilities associated with instructing as well as the characteristics related to being a professional.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

These are the characteristics that will make you a great flight instructor, and the responsibilities of being one.

Overview

Review Objectives and Elements/Key ideas

What

This lesson discusses the scope of responsibilities for instructors and enumerates methods they can use to enhance their professional image and conduct.

Why

It is important that aviation instructors not only know how to teach, but they also need to project a knowledgeable and professional image.

How:

1. **Aviation Instructor Responsibilities** FI.I.E.K1
   A. Helping Learners FI.I.E.K1a
      i. Learning should be enjoyable and interesting
      ii. Standards, and measurement against standards are key to helping learners
         a. Learners need to see growth; people are proud of the successful achievement of difficult goals
   B. Providing Adequate Instruction FI.I.E.K1b
      i. Carefully and correctly analyze each learner's personality, thinking, and ability
         a. The same instruction may not be equally effective for each learner
      ii. Incorrectly analyzing a learner may result in the instruction not producing the desired outcome
      iii. Learners experiencing slow progress due to discouragement/lack of confidence should be assigned sub-goals which are easier to attain than the normal learning goals
         a. Complex lessons can be broken down, each element can be practiced, finishing with the full maneuver
         b. As confidence and ability are gained, difficulty should be increased until progress is normal
      iv. Fast learners may assume correcting errors is unimportant since they make few mistakes
         a. This overconfidence may result in faulty performance
         b. For such learners, constantly raise the standard of performance
      v. Individuals learn when they are aware of their errors
         a. But deficiencies should not be invented
   C. Standards of Performance FI.I.E.K1c
      i. Instructors fail to provide competent instruction when they permit their learners to get by with substandard performance, or without thoroughly learning necessary knowledge
         a. The instructor is responsible for instructing to the established standards in the ACS/PTS
      ii. Accepting lower standards to please a learner doesn't improve the learner-instructor relationship
         a. An earnest learner does not resent reasonable standards that are fairly/consistently applied
   D. Emphasizing the Positive FI.I.E.K1d
      i. The way instructors conduct themselves, the attitudes displayed, and the manner instruction is developed contribute to the formation of either positive or negative impressions by their learners
      ii. Success depends on the ability to present instruction that develops a positive image of aviation
      iii. Every reasonable effort should be made so instruction is given under the most favorable conditions

iv. Emphasize the positive because positive instruction results in positive learning

E. Minimizing Learner Frustration (Encourage, rather than discourage) FI.I.E.K1e
   i. Motivate Learners
      a. More can be gained from wanting to learn than being forced to learn
         - When learners see the benefits or purpose of a lesson their enjoyment/efforts will increase
   ii. Keep Learners Informed
      a. Learners feel insecure when they don't know what is expected or what will happen to them
         - Tell learners what is expected of them and what they can expect in return
      b. Keep learners informed by:
         - Giving them an overview of the course, keeping them posted on progress and giving adequate notice of exams, assignments, or other requirements
         - Talk about money when necessary
   iii. Approach Learners as Individuals – Each person has a unique personality that should be considered
   iv. Give Credit When Due
      a. Praise/credit from the instructor usually is ample reward and provides an incentive to do better
      b. Praise pays dividends, but when given too freely it becomes valueless
   v. Criticize Constructively
      a. It is important to identify mistakes and failures
      b. If the learner is briefed on the errors AND is told how to correct them, progress can be made
   vi. Be Consistent
      a. Learners have a keen interest in knowing what is required to please the instructor
      b. The instructor's philosophy and actions must be consistent to avoid learner confusion
   vii. Admit Errors
      a. Respect can be earned by honestly acknowledging mistakes
         - No one is perfect. If in doubt, admit it
      b. Covering up mistakes tends to destroy confidence
   viii. Be Well Prepared (Over prepare)
      a. Learners are spending *a lot* of money and deserve a well-prepared instructor

2. **RM: Flight Instructor Responsibilities** (RM: Fulfilling Instructor Responsibilities) FI.I.E.K2, FI.I.E.R1
   A. Mold the learner into a safe pilot who takes a professional approach to flying
   B. Be current and proficient in the aircraft & encourage each pilot to learn as much as possible
   C. Physiological Obstacles for Flight Learners
      i. Learners may react to negative factors – Do not ignore the factors or ridicule the learners
         a. Fear of small aircraft, strange noises, G-forces/Motion sickness, etc.
      ii. Negative sensations can often be overcome by understanding the nature of their causes
   D. Ensuring Learner Skill Set
      i. Responsibility to provide guidance and restraint with respect to solo ops
         a. By far the most important responsibility since the instructor is the only person in a position to make the determination that a learner is ready for solo ops
      ii. Before endorsing solo flight, the learner should display consistent ability to perform the maneuvers
         a. The learner should also be capable of handling ordinary problems that might occur
      iii. Provide adequate instruction for each item in the applicable ACS/PTS, including "special emphasis areas"
      iv. Be current on the latest procedures regarding training, certification, and safety
      v. Maintain a current library of information
   E. Pilot Supervision & Surveillance
      i. Instructors have the responsibility to provide guidance & restraint with respect to solo operations
      ii. Does not stop at solo
         a. Responsibility to train competent, safe, and smart pilots who will be an asset to the aviation community

b. Instill risk management and ADM, as well as good, safe habits, and recognize/remove bad habits

3. Qualifications & Professionalism FI.I.E.K3

A. Qualifications
   i. Be thoroughly familiar with the functions, characteristics, and use of all flight instruments/avionics/systems
   ii. Maintain familiarity with current pilot training techniques and certification requirements
      a. Frequent review of new periodicals/technical publications, personal contacts with FAA inspectors/DPE
      b. Participate in pilot & instructor clinics and interact with veteran flight instructors

B. RM: Professionalism (RM: Exhibiting Professionalism) FI.I.E.R2
   i. The instructor is the central figure in aviation training and bear responsibility for all phases of training. The instructor needs to be professional

Instructor Do's
Be professional at all times.
Be sincere.
Present a professional appearance and personal habits.
Maintain a calm demeanor.
Practice safety and accident prevention at all times.
Avoid profanity.
Define common terms.
Continue professional development.
Minimize learner frustration.
Motivate the learner.
Keep the learner informed.
Approach each learner as an individual.
Give credit when due.
Criticize constructively.
Be consistent.
Admit errors.

Instructor Don'ts
Ridicule the learner's performance.
Use profanity.
Model irresponsible flight behaviors.
Say one thing but do another.
Forget personal hygiene.
Disrespect the learner.
Demand unreasonable progress.
Forget the learner is new to aviation jargon.
Set the learner up for failure.
Correct errors without an explanation of what went wrong.

   ii. Sincerity
      a. Always be straight forward and honest
      b. Do not attempt to hide some inadequacy behind a smokescreen or unrelated instruction
         - Any façade can cause the learner to lose confidence and adversely affect learning
   iii. Acceptance of the Learner
      a. The instructor must accept all learners as they are, including all faults and problems
      b. Under no circumstance should the instructor do something which implies degrading the learner
      c. Acceptance, rather than ridicule, and support, rather than reproof, will encourage learning
   iv. Personal Appearance and Habits
      a. Instructors are expected to be neat, clean, and appropriately dressed
         - Attire worn should be to a professional status
      b. Personal habits have a significant effect on the professional image
         - Exercising common courtesy is perhaps the most important of these
            a A rude, thoughtless, inattentive instructor cannot hold anyone's respect
         - Personal cleanliness is important as well (it can be distracting)
   v. Demeanor
      a. Attitude and behavior can contribute much to a professional image
         - Requires development of a calm, thoughtful, and disciplined, but not somber, demeanor
      b. Instruction is best done with a calm, pleasant, thoughtful approach putting the learner at ease
      c. The instructor must constantly portray competence in the subject matter and genuine interest in the

learner's well being
- vi. Proper Language
  - a. Speak normally, without inhibitions, and speaks positively and descriptively, without profanity

4. Professional Development FI.I.E.K4

- A. Successful, professional aviation instructors do not become complacent or satisfied with their own qualifications and abilities, and are constantly alert for ways to improve their qualifications, effectiveness, and the services they provide to learners
- B. The instructor needs a steady supply of fresh material to make instruction interesting and up to date
  - i. Keep well informed with what is being written in current aviation publications
- C. Continuing Education
  - i. Continually update knowledge and skill
  - ii. Government
    - a. FAA seminars, articles, regulations, ACs, etc.
    - b. Pilot Proficiency Awards Program
    - c. Gold Seal Flight Certificate
  - iii. Educational/Training Institutions (attend classes at community colleges, technical schools, etc.)
  - iv. Commercial Organizations (training material and training courses)
  - v. Industry Organizations (articles, publications, training programs)
- D. Sources of Material
  - i. Maintain access to current flight publications (regulations, AIM, PTS, ACS, ACs, etc.)
  - ii. Commercial handbooks, periodicals, technical journals

5. Instructor Ethics & Conduct FI.I.E.K5

- A. A formal code of conduct/ethics promotes safety, good judgement, ethical behavior, and personal responsibility
  - i. Flight Instructors Model Code of Conduct (FIMCC) provides a vision to help instructors build relationships with their learners
- B. Remember you are teaching a pilot who should:
  - i. Make safety the #1 priority
  - ii. Develop and exercise good judgment in making decisions
  - iii. Recognize and manage risk effectively
  - iv. Be accountable for their actions
  - v. Act with responsibility and courtesy
  - vi. Adhere to prudent operating practices and personal operating parameters
  - vii. Adhere to applicable laws and regulations
  - viii. Seek proficiency in control of the aircraft
  - ix. Use flight deck technology in a safe and appropriate way
  - x. Be confident in a wide variety of flight situations
  - xi. Be respectful of the privilege of flight

Conclusion

Brief review of the main points

I.F. Elements of Effective Teaching (Risk Management & Accident Prevention)

References: Aviation Instructor's Handbook (FAA-H-8083-9)

Objectives	The learner should develop knowledge of the elements related to managing and mitigating risk and its application to effective teaching per the Instructor ACS.
Elements	1. Principles of Risk Management 2. Risk Management Process 3. Level of Risk 4. Assessing Risk 5. Mitigating Risk 6. Risk Management Tools 7. Teaching Risk Management 8. ADM, CRM, & SRM
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can not only recognize potentially hazardous situations and effectively mitigate risk but can teach practical risk management.

Instructor Notes:

Introduction:

Attention

We're pilots, we like the rush of flight and the sense of danger. All FAA operations in the United States involve risk; don't let the risk and danger get out of control.

Overview

Review Objectives and Elements/Key ideas

What

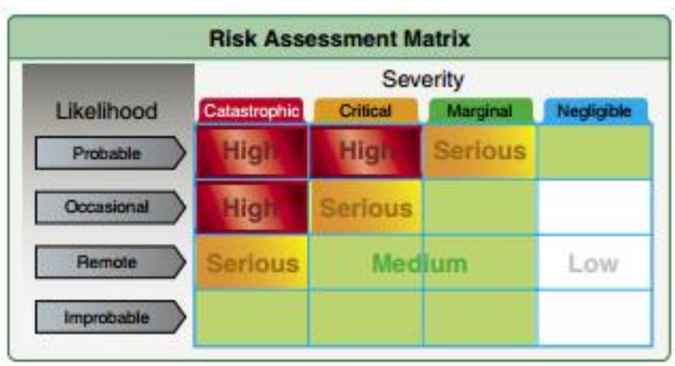
Risk management is a decision-making process designed to perceive hazards systematically, assess the degree of risk associated with a hazard, and determine the best course of action.

Why

Flying is inherently dangerous, but there are ways to keep the danger to a minimum. This lesson will describe ways to recognize and mitigate the risk involved with flying.

How:

1. **Principles of Risk Management**
   A. The goal of risk management is to proactively identify safety-related hazards and mitigate the associated risks
   B. Accept no Unnecessary Risk
      i. Only accept the necessary risk
         a. Flying is impossible without risk, do not make a situation more dangerous than necessary
   C. Make Risk Decisions at the Appropriate Level
      i. In single pilot situations, the pilot makes decisions (not ATC, or passengers)
      ii. In other situations, it may be beneficial to "go up the ladder" for a decision
         a. i.e. Talk to the chief pilot or experienced CFI about a potentially risky situation
   D. Accept Risk When Benefits Outweigh the Costs
      i. Analyze costs and benefits, make an informed decision
   E. Integrate Risk Management into Planning at All Levels
      i. Safety requires risk management planning in all stages of flight
         a. Plan early and throughout to avoid unnecessary, amplified risk
2. **Risk Management Process** FI.I.F.K1
   A. Step 1: Identify the Hazard
      i. A hazard is any real or potential condition that can cause degradation, injury, illness, death, damage to or loss of equipment or property
   B. Step 2: Assess the Risk
      i. Pilots must differentiate *in advance* between a low risk flight and a high-risk flight
      ii. Measured in terms of
         a. Probability, or likelihood, that a hazard will cause a loss
         b. Severity , or the extent of the possible loss
      iii. Develop a method, like the Risk Assessment Matric (pictured) to tangibly measure risk
         a. Likelihood (probability of occurrence): Probable, Occasional, Remote, Improbable



- i.e. Likelihood of a pilot flying MVFR to encounter IFR conditions

b. Severity: Catastrophic, Critical, Marginal, Negligible
- i.e. If pilot is not IFR rated how severe could the consequences be

c. High Likelihood/Severity is bad and vice versa

C. Step 3: Mitigate the Risk

i. Analyze options to reduce, mitigate, or eliminate unnecessary risk
a. i.e., cancel/delay the flight, bring a CFI or more experienced pilot, take another route, etc.

ii. All risks have 2 components: Probability of occurrence & Severity of the hazard
a. Try to reduce or eliminate at least one component

iii. Use a Cost/Benefit analysis to decide if it is worth accepting the risk

iv. By reducing risk to acceptable levels, pilots can complete flights safely/ensure alternate options as required

3. Risk Management Tools FI.I.F.K2

A. PAVE Checklists FI.I.F.K2a

i. Another way to mitigate risk

ii. The risks of flight are divided into 4 categories
a. Once the risks have been identified, decide whether the risk or combination or risks can be managed safely and successfully. If not, the flight should be cancelled

iii. **P**ilot in Command: Am I ready? (IMSAFE Checklist, proficiency, recency, currency, etc.)

iv. **A**ircraft: Is the aircraft appropriate for the trip?
a. Maintenance, Landing Distance, Performance Capabilities, Equipment, Fuel load, Altitude, etc.

v. En**V**ironment: Weather, Terrain, Airports, Airspace, Day/Night, etc.

vi. **E**xternal Pressures: Influences outside of the flight that create pressure to complete the flight, often at the expense of safety
a. This is the most important key to risk management because it is the one risk factor category that can cause a pilot to ignore all the other risk factors
b. Follow your own personal operating procedures (don't bend the rules for anyone), plan for delays, and manage passenger's expectations to reduce external pressure

B. 5P Checklist

i. Used to evaluate the situation at key decision points during the flight, or when an emergency arises
a. Very helpful part of Single Pilot Resource Management (SRM)
b. Based on the idea that the pilot has five variables that impact the environment and lead to a decision
c. At least 5 times before & during the flight, review and consider the 5 P's and make the appropriate decision required by the current situation
- Decision points: Preflight, pre-takeoff, hourly or at the midpoint of flight, pre-descent, and just prior to the final approach fix or entering the pattern

ii. 5 P's:

a. Plan
- The mission. Contains: planning, weather, route, fuel, publication currency, etc.
- Always changing (weather changes, delays, restrictions, etc.), adjust with it

b. Plane
- Condition, abilities (performance, automation, database currency, etc.), equipment, systems, etc.

c. Pilot
- IMSAFE - Recognize and review your physiological situation

d. Passengers
- Passenger's desires can influence decision making and risk management
  a Plan ahead as much as possible
- Ensure passengers are involved in decision making process

    a Ensure they understand risk involved in situations
        1. i.e., IFR approach below minimums or takeoff with IFR below landing minimums
  - Understand what passengers want to do
    a They may be more risk averse than you

e. Programming
  - Plan in advance when and where programming approaches/route changes, and airport information gathering should be accomplished & should not be accomplished
  - Familiarity with the equipment, route, local air traffic control environment, and personal capabilities should drive when, where, and how the automation is programmed and used

C. Flight Risk Assessment Tools (FRAT) FI.I.F.K2b

i. Enables proactive hazard identification, is easy to use, and visually depicts risk
   a. Variety of FRATs available

ii. Formal process using pen and paper to help remove personal desires and emotion from decision making
   a. Determine an acceptable level of risk for flight based on type of operation, environment, aircraft, etc.
      - Create realistic numerical thresholds (min of 3) that trigger additional levels of scrutiny, for example:
        a Green (medium): Good to fly, mitigate risk as able
        b Yellow (serious): Some risk needs to be reduced before departure
        c Red (high): Do not fly until risk is reduced/mitigated
      - Fixed list of hazards are scored based on severity
      - When risk exceeds the acceptable level, reevaluate hazards and reduce risk
        a If risk cannot be reduced, don't fly

iii. National Business Aviation Association (NBAA) Flight Risk Assessment Tool

D. IMSAFE Checklist

i. Mitigate risk by determining your own physical and mental readiness for flight
   a. Illness – Symptoms?
   b. Medication – Taking any?
   c. Stress – Family, money, relationships, work, etc.
   d. Alcohol – Been drinking?
   e. Fatigue – Well rested?
   f. Emotion – Emotionally upset?

4. Teaching Risk Management

A. When & How FI.I.F.K3

i. Most beneficial if RM is taught first (lesson 1) and then integrated into the rest of training (ground & flight)

ii. Should be included in all preflight and postflight briefings
   a. Encourage learner participation and as experience increases, have the learner lead

iii. Include in recurrent, transition, flight reviews, IPCs, etc.

B. Teaching Techniques by Phase of Instruction FI.I.F.K4

i. Private Pilot
   a. Pre-Solo
      - Part of every preflight & postflight brief
      - Introduce a non-numerical FRAT and demo its use. Learner can conduct basic RM analysis by solo
   b. Post-Solo to XC
      - Perform risk analysis of planned flight with some help from instructor
      - Instructor reviews RM prior to solo flight, and learner debriefs instructor on RM aspects of the flight
   c. XC
      - Learner masters RM techniques
      - Learner completes a full risk analysis for every flight and reviews it with instructor

- ii. Instrument
  - a. Emphasize broad risk management techniques to analyze/evaluate complex weather & other elements
    - Ex: single engine plane or over terrain > SE service ceiling of a twin, night flight, low IMC, icing, etc.
- iii. Transition
  - a. Employ scenarios emphasizing RM aspects of the new plane (performance, equipment, procedures, etc.)
  - b. Additionally, emphasize SRM skills (automation management, task/workload management, SA)
- iv. Recurrent, Flight Reviews, IPCs
  - a. Very likely that it has been a while since the learner has been exposed to RM training
  - b. Use scenarios that mirror the pilot's typical operating profile
- v. Operational Flights
  - a. Encourage operational pilots to practice RM on all their flights
    - Goal is to provide guidance allowing pilots to think of RM intuitively as part of every flight
  - b. Scale RM procedures to match the complexity of the flight
    - Ex: For a local flight, use PAVE to brief major risk elements, for a complex flight, use a FRAT
- vi. Professional Pilots
  - a. Most professional pilots encounter RM and more (TEM, CRM, etc.) training at their jobs
  - b. Emphasize RM factors specific to the training/flying outside of their job
    - Ex. GA flying, airspace considerations, single-pilot operations, etc.

C. RM: Managing Risk during Flight Instruction (RM: Hazards associated with instruction) FI.I.F.K5, FI.I.F.R1

- i. Overview
  - a. Same RM techniques as taught to learners apply to the instructor
  - b. Maintain SA of aircraft state, traffic, weather, airspace, and what the learner is doing/planning to do
- ii. Common Flight Instruction Risks FI.I.F.K5a
  - a. Identify risks using the PAVE acronym (Pilot, Aircraft, Environment, External Pressures)
    - Instructor should involve the learner in every step of the assessment & mitigation process
    - General examples below
  - b. Pilot
    - Includes learner & instructor pilot
    - Qualification risks
      - a Learner: Generally, less qualified than the instructor
      - b Instructor: Qualification, currency, and proficiency requirements
        - 1. Be very familiar with aircraft avionics, procedures – unfamiliarity creates a hazard
    - Aeromedical risks
      - a Instructor needs to be in tune with their aeromedical state as well as the learner's
    - Flight Risks
      - a Be prepared for the learner to make mistakes
      - b Mitigation: Proactive planning based on conditions, providing time & space to allow the learner to practice and allow the instructor to takeover if necessary
  - c. Aircraft
    - Maintenance
      - a May not always be under the direct maintenance supervision and control of the instructor
    - Payload & performance requirements & considerations based on the flight
  - d. EnVironmental
    - Collision Hazards
      - a Crowded airspace
      - b Restricted visibility due to haze, pollution, or other factors
    - Complex airspace

e. External
- Scheduling problems, which can be aggravated by aircraft problems, weather, etc.
- Learners are subject to work, family, finances, and other issues

iii. Best Practices FI.I.F.K5b

a. Follow RM procedures discussed in this lesson

b. Always include the learner in RM
- Instructor & learner are responsible for see & avoid, NOTAMs, TFRs, aircraft airworthiness, etc.)

c. PAVE
- Pilot: Be familiar with aircraft & avionics before instructing, IMSAFE, etc.
- Aircraft: Determine airworthiness, resolve any concerns (include the learner in the process)
- Environment: Emphasize precise risk assessment & mitigation with learner (terrain, weather, etc.)
  - a Risks from weather, terrain, night operation, airports, airspace, etc.
  - b If conditions do not support the plan (i.e., stalls & slow flight but the weather is marginal VFR), coach the learner to identify risks involved in practicing stalls/slow flight in these conditions
    1. Adjust as required – i.e., pattern only, simulator flight, or reschedule
- External: Be conscious of learner's limitations, concerns & other factors that can affect performance
  - a Can create the most insidious of hazards & risks
  - b Change the schedule, the plan (i.e., ground vs flight instruction), or end early as required

iv. Takeoff & Landing Considerations FI.I.F.K5c

a. Takeoff
- Time for an aircraft to begin the takeoff and start a climb is only a few seconds
  - a Not enough time to teach effectively
  - b Learner is focused on the takeoff and likely does not have the attention to listen and learn
  - c Majority of teaching should be done prior to contacting tower/advising CTAF of takeoff
- Imperative that the instructor creates realistic training scenarios
  - a Should mimic what the learner will encounter in real life
    1. Short-field takeoff: Specify where an imaginary obstacle exists
  - b Don't create unnecessary hazards (ex. unsafe climb rates or pitch attitudes)
- Be aware of and adjust for other aircraft
  - a Wake turbulence, in-trail spacing and separation from other aircraft

b. Landing
- Don't teach landings mechanically
  - a Instead, convey problems & solutions based on the specific approach
  - b Teach the learner to adjust based on the aircraft, environment, conditions, and performance
- Teach when the student can listen and absorb
  - a Landing can require high concentration and increased stress
  - b Use concise prompting on approach to landing to fix/teach
- Certain landings present unique risks
  - a Be aware of the associated risks
    1. Strong crosswinds, low approach speeds for short fields, anything reducing safety margins
  - b Anticipate potential landing errors and risks based on the maneuver

5. RM: **Obstacles to Maintaining SA** FI.I.F.R2

A. Distraction

i. Contributing factor in many accidents

ii. Minor problem can result in neglecting proper control of the aircraft

iii. Divide attention – flying always comes first

B. Fatigue

i. Impairs alertness and performance
ii. Two major phenomena: Sleep loss & circadian rhythm disruption
iii. Normal response to many flight operation conditions
    a. Low pressure, humidity, noise, and vibration makes pilot susceptible to sleep fatigue
iv. Only effective treatment is sleep

C. Complacency
    i. Overconfidence from repeated experience
    ii. Reduces effectiveness in the flight deck
    iii. Difficult to recognize
        a. Be especially alert to complacency in learners with significant experience
        b. Advanced avionics can promote complacency and inattention
    iv. Exercises to recognize complacency and situational awareness
        a. Ask about positions of other aircraft in the pattern, instrument indications, and the aircraft's location in relation to references
        b. Focus the learner's attention on an imaginary problem
            - Point out that SA is not being maintained if the learner diverts too much attention from other tasks

6. ADM, CRM, & SRM FI.I.F.K6

A. Aeronautical Decision Making (ADM)
    i. A systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances
    ii. Teaching pilots to make sound decisions is the key to preventing accidents
        a. It is estimated that approximately 80% of all aviation accidents are a result of human factors
    iii. Decision Making Process
        a. Define the Problem
            - Recognize a change has occurred or an expected change did not occur
            - Critical error: Incorrectly defining the problem
                a Attempting to solve a problem that may not exist or be the cause of the change
                b Wastes time and energy and distracts from flying
            - Choose a Course of Action
                a Evaluate the need to react, determine actions to resolve the situation in the time available
                b Consider the expected outcome of each action and associated risks
            - Implement the Decision and Evaluate the Outcome

B. RM: Factors Affecting Decision Making (RM: Recognizing & Managing human behavior hazards) FI.I.F.R3
    i. Hazardous Attitudes
        a. Attitude affects the quality of decisions
            - 5 hazardous attitudes that can interfere with the ability to make sound decisions
                a Contribute to poor judgement
            - Recognizing is the first step to neutralizing these attitudes
                a Once recognizing a thought as hazardous, label it as hazardous and state the antidote

b. Attitudes & Antidotes

The Five Hazardous Attitudes	Antidote
Anti-authority: "Don't tell me." This attitude is found in people who do not like anyone telling them what to do. In a sense, they are saying, "No one can tell me what to do." They may be resentful of having someone tell them what to do or may regard rules, regulations, and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.	**Follow the rules. They are usually right.**
Impulsivity: "Do it quickly." This is the attitude of people who frequently feel the need to do something, anything, immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind.	**Not so fast. Think first.**
Invulnerability: "It won't happen to me." Many people falsely believe that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. However, they never really feel or believe that they will be personally involved. Pilots who think this way are more likely to take chances and increase risk.	**It could happen to me.**
Macho: "I can do it." Pilots who are always trying to prove that they are better than anyone else think, "I can do it—I'll show them." Pilots with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.	**Taking chances is foolish.**
Resignation: "What's the use?" Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get them or attribute it to bad luck. The pilot will leave the action to others, for better or worse. Sometimes, such pilots will even go along with unreasonable requests just to be a "nice guy."	**I'm not helpless. I can make a difference.**

ii. Stress Management
  a. Learning to cope with stress is an effective ADM tool
  b. A certain amount of stress is good – keeps you alert and prevents complacency
    - Stress is cumulative, too much can amount to an intolerable burden
    - Performance increases with the onset of stress, peaks, then falls rapidly as stress gets too high
  c. Stressors can increase risk of error
    - Physical: Associated with the environment (temperature, noise, vibration, lack of oxygen)
    - Physiological: Physical conditions (fatigue, lack of physical fitness, missed meals)
    - Psychological: Social or emotional factors (divorce, death in the family, sick child)
  d. Recognize when stress is affecting a learner
    - Seems distracted or has a difficult time accomplishing the tasks
    - Try to determine the cause (doesn't have to be specific, could be a private matter)
    - To help learners, instructors can recommend actions
      a Have them self-assess then set realistic goals - Delay training, if necessary
      b Put the learner and their progress first

C. Single Pilot Resource Management (SRM) / Crew Resource Management (CRM)
  i. What is it?
    a. How to gather information, analyze it, and make decisions
    b. Application of team management concepts in the flight deck environment
      - Includes all groups working with the flight crew involved in decisions to operate a flight safely
        a Pilots, dispatchers, cabin crew, maintenance, ATC

ii. Use of Resources
    a. Use all available resources
        - Think outside the box
    b. Internal Resources
        - Found in the flight deck during flight
            a Equipment, systems, charts, books, etc.
            b Ingenuity, knowledge, and skill
            c Other passengers (even if they are not pilots)
    c. External Resources
        - ATC and flight service specialists
            a Traffic advisories, vectors, weather info, emergency assistance
    d. Workload Management
        - Plan, prioritize, and sequence to prevent overload
        - Prepare for high workload situations
            a Don't wait until you're in the situation
            b i.e., prepare for the approach before it begins
        - Be able to recognize high workloads
            a Faster paced work along with divided attention
            b Stay ahead as much as possible to prevent high workloads
            c Manage tasks in order of importance when behind

iii. 5 P's Check, as discussed is a very helpful to (SRM)

Conclusion:
Brief review of the main points
It is extremely important that a pilot (especially a student pilot) can recognize and effectively mitigate risk to provide a safe flight. This chapter provided many factors to consider and ways to reduce the inherent risk associated with flying.

TECHNICAL SUBJECT AREAS

II.A. Human Factors

References:
Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25); Chapter 17 pgs. 1-19
Airplane Flying Handbook (FAA-H-8083-3) Chapter5 pg. 3
AIM – Chapter 8

Objectives	The learner exhibits knowledge regarding human factors as required in the Instructor ACS.
Key Elements	1. IM SAFE – Self Checklist 2. Trust the instruments 3. Carbon Monoxide is 200x more likely to bond with blood than oxygen
Elements	1. Hypoxia 2. Hyperventilation 3. Middle Ear and Sinus Problems 4. Spatial Disorientation 5. Motion Sickness 6. Carbon Monoxide Poisoning 7. Fatigue and Stress 8. Dehydration 9. Hypothermia 10. Optical Illusions 11. Nitrogen and Scuba Diving 12. Alcohol and Other Drugs 13. ADM, CRM, & SRM
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can explain different aeromedical factors, and their importance to flying and possible effects during flight.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Safety in the aircraft requires knowledge of the factors that can lead to negative consequences if we were unaware or unable to treat them. Hypoxia, for example, can result in symptoms of euphoria and the inability to make any sort of rational decision, which is obviously not a good thing while you're trying to fly a plane. (There are many good hyperbaric chamber/hypoxia videos on you tube)

Overview

Review Objectives and Elements/Key ideas

What

Human factors involve several health and physiological factors that can influence a pilot and his or her ability to fly safely. Some are minor, while others require special attention to ensure safety and survival.

Why

Many of these factors not only affect the health and well-being of the pilot but can quickly lead to in-flight emergencies.

How:

1. **Hypoxia** AI.II.A.K1a
   A. Hypoxia means "reduced oxygen" or "not enough oxygen"
      i. The greatest concern is getting oxygen to the brain, since it is particularly vulnerable to oxygen deprivation
      ii. Hypoxia can be caused by several factors including:
         a. An insufficient supply of oxygen
         b. Inadequate transportation of oxygen
         c. Inability of the body tissues to use oxygen
   B. Hypoxic Hypoxia
      i. A result of insufficient oxygen available to the lungs
      ii. A blocked airway or drowning are examples of how the lungs can be deprived of oxygen
      iii. For Pilots: The reduction in partial pressure of oxygen at high altitude is a common example
         a. Partial Pressure: amount of pressure that a single gas (out of a mixture) contributes to the total pressure
      iv. Although the percentage of oxygen in the atmosphere is constant with changes in altitude, partial pressure decreases as altitude increases
         a. As you ascend, the percentage of each gas remains the same, but the molecules no longer have the pressure required to drive oxygen into the respiratory system
         b. The decrease of oxygen molecules at sufficient pressure leads to hypoxic hypoxia
   C. Hypemic Hypoxia
      i. Occurs when the blood is not able to take up and transport sufficient oxygen to the cells in the body
      ii. Hypemic means "not enough blood"
      iii. This type of hypoxia is a result of oxygen deficiency in the blood
      iv. Possible Causes:
         a. Not enough blood volume
            - Can be caused by severe bleed or blood donation
         b. Certain blood diseases, such as anemia

   c. Hemoglobin, the molecule that transports oxygen, is unable to bind oxygen molecules
   d. Carbon monoxide poisoning

D. Stagnant Hypoxia
   i. Stagnant means "not flowing;" stagnant hypoxia results when the oxygen rich blood in the lungs isn't moving to the tissues that need it
      a. Ex. An arm or leg "falling asleep" because the blood flow has been restricted
   ii. This type of hypoxia can result from:
      a. Shock
      b. The heart failing to pump blood effectively
      c. A constricted artery
   iii. During flight, stagnant hypoxia can occur when pulling excessive positive Gs
   iv. Cold temperatures can also decrease the blood supplied to extremities

E. Histotoxic Hypoxia
   i. The inability of the cells to effectively use oxygen
      a. "Histo" refers to tissues or cells, and "Toxic" means poison
   ii. In this case, oxygen is being transported to the cells, but they are unable to use it
   iii. Causes:
      a. Alcohol and other drugs, such as narcotics and poison
      b. Drinking an ounce of alcohol is equivalent to an additional 2,000' of altitude

F. Symptoms of Hypoxia
   i. The first symptoms are euphoria and a carefree feeling. With increased oxygen starvation, the extremities become less responsive and flying becomes less coordinated.
   ii. As it worsens, vision narrows, concentration and instrument interpretation become difficult
   iii. Common symptoms include:
      a. Cyanosis (blue fingernails and lips)
      b. Headache
      c. Delayed reactions
      d. Impaired judgment
      e. Euphoria
      f. Visual Impairment
      g. Drowsiness
      h. Lightheaded or dizzy sensation
      i. Tingling in fingers or toes
      j. Numbness
   iv. Even with all of these symptoms, the effects of hypoxia can cause a pilot to have a false sense of security and be deceived into believing that everything is normal (euphoria)

G. Useful Consciousness
   i. Describes the maximum time the pilot has to make rational, lifesaving decisions and carry them out at a given altitude without supplemental oxygen
   ii. Above 10,000 ft., symptoms increase in severity, and time of useful consciousness rapidly decreases

Altitude	Time of Useful Consciousness
45,000 ft. MSL	9 to 15 seconds
40,000 ft. MSL	15 to 20 seconds
35,000 ft. MSL	30 to 60 seconds
30,000 ft. MSL	1 to 2 minutes
28,000 ft. MSL	2 ½ minutes to 3 minutes
25,000 ft. MSL	3 to 5 minutes
22,000 ft. MSL	5 to 10 minutes
20,000 ft. MSL	30 minutes or more

H. Treatment
   i. Flying at lower altitudes (Emergency Descent)
   ii. Use supplemental oxygen immediately

- I. FAA Physiology Training – One day course in OK. Altitude chamber and vertigo demonstrations
  - i. Experiencing and witnessing the effects of hypoxia can be very helpful to recognizing its onset

2. Hyperventilation AI.II.A.K1b

- A. Occurs when experiencing emotional stress, fright, or pain, and the breathing rate and depth increase
  - i. Result is an excessive loss of carbon dioxide from the body, which can lead to unconsciousness while the respiratory system attempts to override your actions and regain control of breathing
- B. Pilots encountering a stressful situation may unconsciously increase their breathing rate
  - i. At higher altitudes, with or without oxygen, a pilot may tend to breathe more rapidly than normal, which can lead to hyperventilation
- C. Hyperventilation symptoms are similar to hypoxia so it's important to treat the proper condition
- D. Common Symptoms:
  - i. Visual Impairment
  - ii. Unconsciousness
  - iii. Lightheaded or dizzy sensation
  - iv. Tingling sensations
  - v. Hot and cold sensations
  - vi. Muscle spasms
- E. Treatment
  - i. Involves restoring the proper carbon dioxide level in the body
  - ii. If using supplemental oxygen, check the equipment and flow rate to ensure it's not hypoxia
    - a. If unsure, hypoxia is the more threatening situation and should be treated
  - iii. Breathing normally is the best prevention and the best cure for hyperventilation
  - iv. Breathing into a paper bag or talking aloud helps
  - v. Recovery is usually rapid once breathing is returned to normal

3. Middle Ear and Sinus Problems AI.II.A.K1c

- A. Middle Ear Problems
  - i. Explanation
    - a. Difference between the outside air pressure and the air inside the middle ear and nasal sinuses
    - b. The middle ear is a small cavity located in the bone of the skull
      - Normally, the pressure differences are equalized by the Eustachian Tube
        - a A tube leading from inside each ear to the back of the throat on each side
        - b Tubes are usually closed, but open with chewing, yawning or swallowing to equalize pressure
  - ii. Symptoms
    - a. Pain is the primary indicator
      - Large pressure differences can lead to excessive pain and eardrum damage
    - b. Temporary reduction in hearing sensitivity
  - iii. Relation to flying
    - a. Climb: Eardrum bulges outward as pressure in the eustachian tube remains the same while outside air pressure decreases, resulting in discomfort
    - b. Descent: Eardrum bulges inward causing discomfort as outside pressure increases while pressure in the Eustachian tube remains at altitude
    - c. Excessive pressure in either situation can result in pain and a ruptured ear drum
  - iv. Treatment
    - a. If minor, chew gum or stretch the jaw to attempt to equalize pressure
    - b. Pinch the nostrils, close the mouth, and blow slowly and gently in the mouth and nose
      - Forces air into the Eustachian tube allowing the pressure to equalize
      - May not be possible to equalize the pressure with a cold, an ear infection, or sore throat
      - Be cautious in a climb, forcing air into the Eustachian tube can add more pressure and force the

eardrum farther outward leading to increased pain

c. If experiencing minor congestion, nose drops, or nasal sprays may reduce painful ear blockage

B. Sinus Problems

i. Explanation

a. Air pressure in the sinuses equalizes with the pressure in the flight deck through small openings that connect the sinuses to the nasal passages

b. An upper respiratory infection (cold or sinusitis) or a nasal allergic condition can produce enough congestion to slow equalization

ii. Symptoms

a. Pain over the sinus area (pain can become excessive)

b. Some sinus blocks can make the upper teeth ache

c. Bloody mucus may discharge from the nasal passages

iii. Relation to flying

a. As the difference in pressure increases, congestion may plug the sinus' openings

b. "Sinus block" occurs most frequently during descents

iv. Treatment

a. Use slow descent rates

b. Do not fly with sinus problems

4. Spatial Disorientation AI.II.A.K1d

A. Explanation

i. Orientation: The awareness of the position of the aircraft and of oneself in relation to a specific reference point

ii. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space

iii. The body uses three systems to ascertain orientation and movement in space

a. Visual: The eye, by far the largest source of information

b. Somatosensory: Nerves in the skin, muscles, and joints that, along with hearing, sense position based on gravity, feeling, and sound

c. Vestibular System: A very sensitive motion sensing system located in the inner ears

- Reports head position, orientation, and movement in 3-dimensional space

iv. When all 3 systems agree you have a clear idea of where and how the body is moving

a. When they don't agree is when you become disoriented

B. Relation to flight

i. Flying can result in conflicting information being sent to the brain, leading to disorientation

ii. Visual System (eyes)

a. Flight in VMC

- Eyes are the major orientation system and can usually prevail over false sensations

b. Flight in IMC

- Without visual cues, the eyes can't correct for false sensations which leads to disorientation

iii. Vestibular System (inner ear)

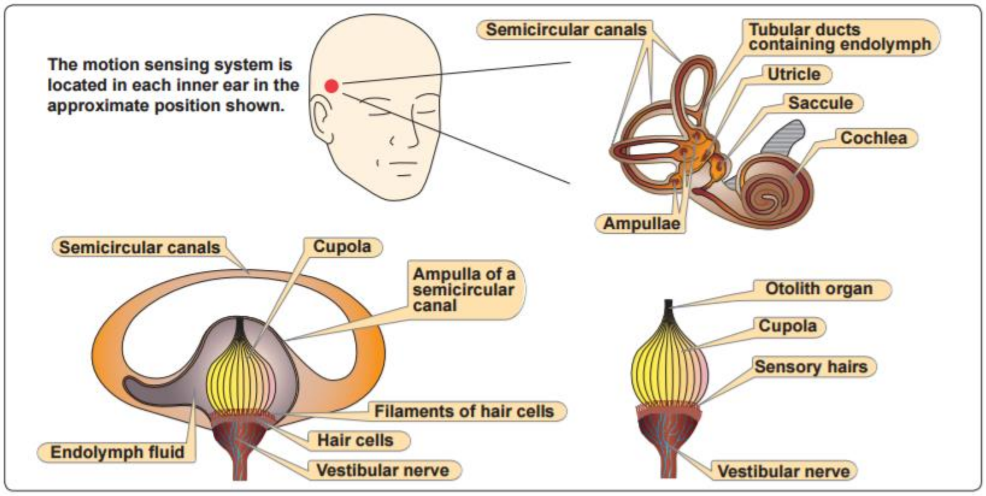
a. Allows the pilot to sense movement and determine orientation in the surrounding environment

b. Two major parts: Semicircular Canals and Otolith Organs

c. Semicircular Canals

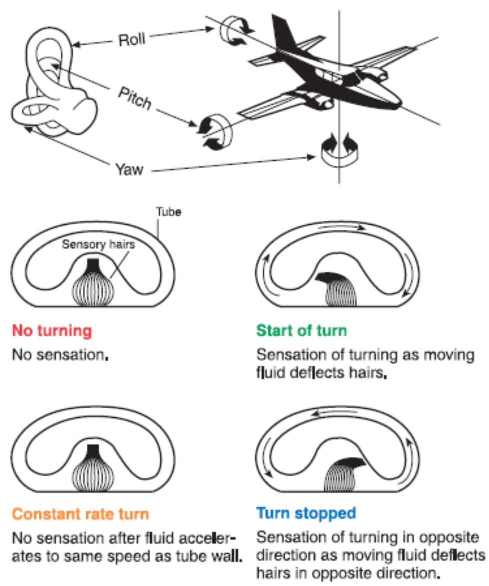
- Explanation
  - a Detect angular acceleration
  - b Three tubes at right angles to each other (one on each axis)
  - c Each canal is filled with Endolymph Fluid
  - d In the center of the canal is the cupola

1. Gelatinous structure resting on sensory hairs at the end of the vestibular nerves



- How they work: In a Turn
    - a Turn Detection
        1. Unaccelerated, Straight & Level Flight
            - a. Hair cells are upright, and the brain doesn't sense a turn
        2. Turning Flight
            - a. Semicircular canal and its fluid are put into motion
            - b. Fluid lags behind the canal walls
            - c. Canal wall and cupola move in the opposite direction of the fluid
            - d. Brain interprets the hair movement as a turn

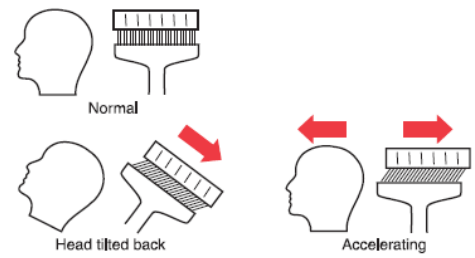
The semicircular tubes are arranged at approximately right angles to each other, in the roll, pitch, and yaw axes.



- b Only detects turns of a short duration
    1. After about 20 seconds, the fluid catches up with the canal walls and the hairs are no longer bent (unaccelerated, straight & level flight)
    2. Hairs detect no relative movement so the sensation of turning ceases
    3. Returning to straight-and-level flight, the fluid moves in the opposite direction
    4. Falsely interpreted as a turn in the opposite direction
        - a. To correct for this, the pilot reenters the original turn
- c Demonstration: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Try it again, but this time once they believe the aircraft is straight, roll out of the bank. The student will feel like the aircraft is turning in the opposite direction.

d. Otolith Organs

- Explanation
    - a Detect linear acceleration/gravity
    - b A gelatinous membrane containing chalk like crystals covers the sensory hairs



   c. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and sensory hairs detect the shift
- Acceleration
   a. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

iv. Somatosensory System (nerves)
   a. Nerves in the body's skin, muscles, and joints constantly send signals to the brain which signals the body's relation to gravity
      - Ex. Acceleration will be felt as the pilot is pushed back into the seat
   b. False Sensations
      - Forces created in turns can lead to false sensations of the direction of gravity
         a. The brain cannot differentiate between the forces of a turn and the force of gravity
      - Turbulence can create motions that confuse the brain
      - Fatigue or illness can exacerbate these sensations

C. Countering the sensations
   i. Recognize the problem, disregard the false sensations, and rely totally on the flight instruments
   ii. Understand the problem and control the aircraft using only instrument indications

5. Motion Sickness AI.II.A.K1e

A. Cause
   i. Caused by the brain receiving conflicting messages about the state of the body
   ii. Anxiety and stress also affect motion sickness
B. Symptoms
   i. General discomfort
   ii. Nausea
   iii. Dizziness
   iv. Paleness
   v. Sweating
   vi. Vomiting
C. Treatment
   i. Open fresh air vents
   ii. Focus on objects outside the airplane
   iii. Avoid unnecessary head movement
   iv. Take control of the aircraft and fly smooth, straight and level
      a. Letting someone else fly can make the situation worse
   v. Usually goes away after a few flight lessons
      a. More used to flying and stress/anxiety are reduced

6. Carbon Monoxide Poisoning AI.II.A.K1f

A. How it Happens – In the Plane
   i. Carbon Monoxide (CO) is a colorless, odorless gas produced by all internal combustion engines
   ii. If the exhaust system is damaged or leaking, heat/defrost vents can provide CO a way into the cabin
B. How it Happens – In the Body
   i. CO attaches itself to the hemoglobin in the blood
      a. It does this about 200 times easier than oxygen
      b. CO prevents the hemoglobin from carrying oxygen to the cells resulting in Hypemic Hypoxia
   ii. Can take up to 48 hours for the body to dispose of CO
   iii. If severe enough, CO poisoning can result in death

C. Effects of CO poisoning
    i. Headache
    ii. Blurred vision
    iii. Dizziness
    iv. Drowsiness
    v. Loss of muscle power
D. Detecting and Correction
    i. Disposable, inexpensive CO detectors are widely available
    ii. If a strong odor of exhaust gases is detected, assume CO is present
        a. CO may be present in dangerous amounts even if no exhaust odor is detected
    iii. If exhaust odor is noticed or symptoms are experienced, immediate actions should be taken
        a. Turn off the heater
        b. Open fresh air vents and windows
        c. Use supplemental oxygen, if available
        d. Land

7. Fatigue and Stress

A. Fatigue AI.II.A.K1h
    i. Effects
        a. Degradation of attention and concentration
        b. Impaired coordination
        c. Decreased ability to communicate
    ii. Causes
        a. Sleep loss
        b. Exercise
        c. Physical work
        d. Stress and prolonged performance of cognitive work can result in mental fatigue
    iii. Categories of Fatigue (Acute and Chronic)
        a. Acute Fatigue (short term)
            - Definition
                a Short term, and a normal occurrence in everyday life
                b Tiredness felt after a period of strenuous effort, excitement, or lack of sleep
            - Skill Fatigue – A special type of acute fatigue affecting piloting skill. Effects include:
                a Timing Disruption
                    1. Appearing to perform a normal task, but the timing of each component is slightly off
                    2. Pattern of operation is less smooth as each component is performed as a separate part instead of part of a single, integrated activity
                b Disruption of the perceptual field
                    1. Concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery
                    2. May be accompanied by a loss of accuracy/smoothness in control movements
            - Causes
                a Mild hypoxia
                b Physical stress
                c Psychological stress
                d Depletion of physical energy resulting from psychological stress
                e Sustained psychological stress
            - Prevention
                a Proper diet

1. Prevents the body from having to consume its own tissues as an energy source
- b Adequate rest and sleep
  1. Maintains the body's store of vital energy
  2. The difference between flying fatigued and rested can be night and day,

b. Chronic Fatigue
- Definition
  - a Fatigue extending over a long period of time
  - b Usually has psychological roots, an underlying disease is sometimes responsible
- Causes
  - a Continuous high-stress levels produce chronic fatigue
- Symptoms
  - a Weakness
  - b Tiredness
  - c Palpitations of the heart
  - d Breathlessness
  - e Headaches
  - f Irritability
  - g Stomach or intestinal problems (rare)
  - h Generalized aches and pains throughout the body
  - i Emotional Illness (when conditions become serious enough)
- Prevention
  - a Usually requires treatment by a physician

iv. Prevention

a. If suffering from acute fatigue, stay on the ground

b. Fatigue in the flight deck cannot be overcome through training or experience

c. Getting adequate rest is the only way to prevent fatigue
- Avoid flying
  - a Without a full night's rest
  - b After working excessive hours
  - c After an especially exhausting or stressful day

d. Suspected chronic fatigue should be treated by a physician

B. Stress AI.II.A.K1g

i. Body's response to physical and psychological demands placed upon it

ii. Body's Reaction

a. Releasing chemical hormones (such as adrenaline) into the blood

b. Increasing metabolism to provide more energy to the muscles

c. Blood sugar, heart rate, respiration, blood pressure, and perspiration all increase

iii. Stressors (elements that cause an individual to experience stress)

a. Physical stress (noise or vibration)

b. Physiological stress (fatigue)

c. Psychological stress (difficult work or personal situations)

iv. Categories of Stress (Acute and Chronic)

a. Acute Stress (short term)
- Involves an immediate threat that is perceived as danger
- The type of stress that triggers a "fight or flight" response in an individual
- Normally, a healthy person can cope with acute stress and prevent stress overload
- On-going acute stress can develop into chronic stress

v. Chronic Stress (long term)
   a. Presents an intolerable burden, exceeds the ability to cope, causes performance to fall sharply
   b. Causes
      - Unrelenting psychological pressures
         a Ex. Loneliness, financial worries, and relationship or work problems
   c. Do not fly. Consult a physician

8. Dehydration & Nutrition AI.II.A.K1i

A. Dehydration
   i. Critical loss of water from the body
   ii. Causes
      a. Hot flight decks/flight lines, wind, humidity, diuretic drinks (coffee, tea, alcohol, caffeinated soda)
   iii. Effects
      a. First noticeable effect is fatigue
         - Top physical and mental performance is difficult, if not impossible
      b. Headache, cramps, tingling, sleepiness, and dizziness
   iv. How it affects flying
      a. Hot temperatures and high altitudes increase susceptibility to dehydration
         - Dry air at altitude increases the body's rate of water loss
      b. Fatigue progresses to dizziness, weakness, nausea, tingling hands & feet, abdominal cramps, and extreme thirst
      c. Attention is taken from flying and skills diminish
   v. Prevention
      a. Carry an ample supply of water (recommended to drink 2 quarts of water per day)
         - Stay ahead – don't wait until you're thirsty to drink
      b. Wear light colored, porous clothing and a hat
      c. Keep the flight deck well ventilated
      d. Limit caffeine and alcohol intake

B. Nutrition
   i. Ensure properly fed and nourished
   ii. Causes: Missing/postponing meals and/or poor eating habits
   iii. Effects
      a. Low energy and/or low blood sugar
      b. Stomach contractions, distraction, breakdown in habit patterns, and shortened attention span
      c. Insufficient vitamin A can impair night vision
   iv. Prevention: Eat healthy, regularly spaced and sized meals

9. Hypothermia AI.II.A.K1j

A. How it Happens
   i. The body loses heat faster than it can be produced
      a. Normal body temperature is 98.6° F (37° C), hypothermia occurs below 95° F (35° C)
   ii. Mechanisms of heat loss
      a. Radiated heat: Most heat loss is due to heat radiated from unprotected parts of the body
      b. Direct contact: In contact with something very cold, heat is conducted away from the body
         - Heat is lost much faster in cold water than cold air
         - Heat loss if much faster if clothes are wet
      c. Wind: Carries away the thin layer of warm air at the surface of your skin

B. Causes
   i. Clothes that aren't warm enough for the weather

ii. Too much time in the cold
iii. Falling into cold water
iv. Unable to get out of wet clothes or move to a warm, dry location

C. Symptoms
i. Shivering
ii. Slurred speech or mumbling
iii. Slow, shallow breathing
iv. Weak pulse
v. Clumsiness
vi. Drowsiness
vii. Confusion or memory loss (can prevent the person from knowing they have hypothermia)
viii. Bright red, cold skin

D. Prevention (COLD)
i. Cover: Wear protective clothing
a. Cover your head, face, and neck. Wear mittens instead of gloves
ii. Overexertion
a. Avoid activities that result in a lot of sweat
b. Wet clothing + cold weather causes body heat to be lost more quickly
iii. Layers
a. Loose fitting, layered, lightweight clothing
b. Wool, silk or polypropylene inner layers hold heat better than cotton
c. Tightly woven, water repellent material is best for wind protection
iv. Dry
a. Stay dry – get out of wet clothing as soon as possible

10. Optical Illusions AI.II.A.K1k

A. Runway Width Illusion
i. Reason
a. A narrower than usual runway
b. A wider than usual runway
ii. Illusion
a. Narrow: Can create the illusion that the aircraft is at a higher altitude than it is
b. Wide: Can create the illusion that the aircraft is at a lower altitude than it is
iii. Result
a. Narrow: The pilot who doesn't recognize this will fly a lower approach, with the risk of striking objects along the approach path or landing short
b. Wide: the pilot who doesn't recognize this will fly a higher approach, with the risk of leveling out high and landing hard or overshooting the runway

B. Runway and Terrain Slope Illusion
i. Reason
a. An up-sloping runway, up sloping terrain, or both
b. A down sloping runway, down sloping terrain, or both
ii. Illusion
a. Upslope: Can create the illusion that the aircraft is at a higher altitude than it is
b. Downslope: Can create the illusion that the aircraft is at a lower altitude than it is
iii. Result
a. Upslope: The pilot who does not recognize this will fly a lower approach
b. Downslope: The pilot who does not recognize this will fly a higher approach

C. Featureless Terrain Illusion

- i. Reason
    - a. An absence of ground features, as when landing over water, darkened areas, and terrain made featureless by snow
- ii. Illusion
    - a. Can create the illusion that the aircraft is at a higher altitude than it is
- iii. Result
    - a. The pilot who doesn't recognize this will fly a lower approach

D. Atmospheric Illusions
- i. Reason
    - a. Rain on the windscreen
    - b. Atmospheric Haze
    - c. Penetration of fog
- ii. Illusion
    - a. Rain - Can create the illusion of greater height
    - b. Atmospheric Haze: Can create the illusion of being a greater distance from the runway
    - c. Penetration of Fog: Can create the illusion of pitching up
- iii. Result
    - a. Rain & Haze: The pilot who does not recognize these illusions will fly a lower approach
    - b. Fog: The pilot who does not recognize this will steepen the approach, often quite abruptly

E. Ground Lighting Illusions
- i. Reason: Lights along a straight path, such as a road, and even lights on moving trains
- ii. Illusions: Can create the illusion of runway and approach lights
- iii. Result: The pilot may attempt to land on a path, road, or train
- iv. Reason: Bright runway and approach lighting systems
- v. Illusion: Can create the illusion of less distance to the runway
    - a. Especially where few lights illuminate the surrounding terrain
- vi. Result: The pilot who does not recognize this illusion will fly a higher approach

F. Preventing Landing Illusions
- i. Anticipate them during approaches
- ii. Aerial visual inspection of unfamiliar airports before landing
- iii. Using glide slope or VASI/PAPI systems whenever possible
- iv. Maintaining optimum proficiency in landing procedures

11. Nitrogen and Scuba Diving AI.II.A.K1l

A. Why it's a Danger
- i. Scuba diving results in a significant increase in the amount of nitrogen dissolved in the body
    - a. The deeper the dive, the greater the nitrogen
- ii. At sea level, the nitrogen inside and outside the body is in equilibrium
- iii. When atmospheric pressure is reduced, nitrogen leaves the body
- iv. If the nitrogen leaves too quickly, bubbles may form causing a variety of symptoms
    - a. Bubbles can form in the bloodstream, spinal cord or brain
    - b. Symptoms include impairment or severe pain - extreme cases can result in death

B. Scuba Diving and Flying
- i. If enough time isn't provided, DCS can occur as low as 5,000' and create an in-flight emergency
    - a. In normal conditions, most cases of DCS occur at altitudes of 25,000' or higher
- ii. Wait at least 12 hrs. after a dive not requiring a controlled ascent before flight up to 8,000' MSL
    - a. 24 hrs. for flight above 8,000'
- iii. Wait at least 24 hrs. after a dive that requires a controlled ascent before flight up to 8,000' MSL
- iv. If a decompression occurs, DCS symptoms can be brought on quickly

12. Alcohol and Other Drugs AI.II.A.K2. AI.II.A.K3

A. DON'T drink and fly
   i. Even in small amounts, alcohol can impair judgement, decrease sense of responsibility, affect coordination, constrict visual field, diminish memory, reduce reasoning ability, lower attention span
      a. Altitude multiplies the effects of alcohol on the brain
      b. Alcohol interferes with the brains ability to utilize oxygen (form of histotoxic hypoxia)
   ii. A hangover can impair anyone attempting to fly
   iii. FAR 91.17 – 8 hrs. 'from bottle to throttle' (8 hrs. and not feeling the effects of alcohol is better)
      a. Considerable amounts of alcohol can remain in the body for over 16 hours – be cautious

B. Medications
   i. FAR 61.53 (Prohibition on operations during medical deficiency) prohibits flying if you:
      a. Are taking medication/receiving treatment that would prevent you from obtaining a medical
   ii. FAR 91.17 prohibits use of drugs affecting a person's faculties in any way contrary to safety
   iii. Medication can absolutely affect pilot performance
      a. Side effects can impair judgment, memory, alertness, coordination, vision, can cause confusion, dizziness, headaches, nausea, mood swings, anxiety, balance problems, hearing problems, etc.
      b. Drugs that cause no apparent side effects on the ground can create serious problems airborne
   iv. Basically: Do not fly while taking any medication(s), unless approved by the FAA

13. ADM, CRM, & SRM AI.II.A.K4

A. RM: Distractions (Task Prioritization, Loss of SA, Disorientation) AI.II.A.R3
   i. Human factors can present significant, distractions, disorientation, and an inability to manage tasks
      a. The pilot must perform an honest evaluation of themselves prior to flight
         - IMSAFE:
            a Illness – Symptoms?
            b Medication – Taking any?
            c Stress – Family, money, relationships, work, etc.
            d Alcohol – Been drinking?
            e Fatigue – Well rested?
            f Emotion – Emotionally upset?
   ii. In flight, be alert to factors that can affect performance and lead to disorientation, etc.

B. RM: Combat confirmation/expectation bias AI.II.A.R4
   i. Your expectations can influence behavior
   ii. Individuals are vulnerable to thinking they see (or hear) what they expect to see (or hear)
   iii. Don't assume everything will be OK, because it's always been OK
   iv. If something doesn't feel right (i.e., hypoxia symptoms), take action

C. Stress Management
   i. Learning to cope with stress is an effective ADM tool
   ii. A certain amount of stress is good – keeps you alert and prevents complacency
      a. Stress is cumulative, too much can amount to an intolerable burden
      b. Performance increases with the onset of stress, peaks, then falls rapidly as stress gets too high
   iii. Stressors can increase risk of error
      a. Physical: Associated with the environment (temperature, noise, vibration, lack of oxygen)
      b. Physiological: Physical conditions (fatigue, lack of physical fitness, missed meals)
      c. Psychological: Social or emotional factors (divorce, death in the family, sick child)
   iv. Recognize when stress affect performance

D. RM: Hazardous Attitudes AI.II.A.R2
   i. Attitude affects the quality of decisions
      a. 5 hazardous attitudes that can interfere with the ability to make sound decisions

- Contribute to poor judgement

b. Recognizing is the first step to neutralizing these attitudes
   - Once recognizing a thought as hazardous, label it as hazardous and state the antidote

ii. Attitudes & Antidotes

The Five Hazardous Attitudes	Antidote
Anti-authority: "Don't tell me." This attitude is found in people who do not like anyone telling them what to do. In a sense, they are saying, "No one can tell me what to do." They may be resentful of having someone tell them what to do or may regard rules, regulations, and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.	**Follow the rules. They are usually right.**
Impulsivity: "Do it quickly." This is the attitude of people who frequently feel the need to do something, anything, immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind.	**Not so fast. Think first.**
Invulnerability: "It won't happen to me." Many people falsely believe that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. However, they never really feel or believe that they will be personally involved. Pilots who think this way are more likely to take chances and increase risk.	**It could happen to me.**
Macho: "I can do it." Pilots who are always trying to prove that they are better than anyone else think, "I can do it—I'll show them." Pilots with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.	**Taking chances is foolish.**
Resignation: "What's the use?" Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get them or attribute it to bad luck. The pilot will leave the action to others, for better or worse. Sometimes, such pilots will even go along with unreasonable requests just to be a "nice guy."	**I'm not helpless. I can make a difference.**

E. Use all Resources

i. Use all available resources – Don't depend solely on yourself

ii. Internal Resources
   a. Equipment (autopilot, GPS, etc.), systems, charts, books, etc.
   b. Ingenuity, knowledge, and skill
   c. Other passengers (even if they are not pilots)

iii. External Resources
   a. ATC, FSS, Guard, etc. (Traffic advisories, vectors, weather info, emergency assistance)

iv. Workload Management
   a. Plan, prioritize, and sequence to prevent overload
   b. Prepare for high workload situations
      - Don't wait until you're in the situation (i.e., prepare for the approach before it begins)
   c. Be able to recognize high workloads
      - Faster paced work along with divided attention
      - Stay ahead as much as possible to prevent high workloads
      - Manage tasks in order of importance when behind
      - "Attack the closest alligator" – Deal with the most pressing/threatening issue

RM: Aeromedical & Physiological Issues AI.II.A.R2

The lesson as a whole is a discussion of managing risk associated with aeromedical issues

Conclusion:
Brief review of the main points
There are many factors a pilot needs to be aware of to ensure a safe flight and to understand the medical risks involved with flying. Recognize conditions and symptoms associated with physiological issues and take action to maintain safety, whether that means supplemental oxygen, trusting the instruments, or diverting and landing as soon as possible.

II.B. Visual Scanning & Collision Avoidance

References:
Airplane Flying Handbook (FAA-H-8083-3) (Chapter 1 pgs. 10-12)
Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25) (Chapter 14 pgs. 28-30, 17 pgs. 7-8
AIM Chapter 8-1-8
Pilot's Role in Collision Avoidance (AC 90-48)

Objectives	The learner should develop knowledge of the elements related to proper visual scanning and collision avoidance, as well as illusions and their effect on the pilot.
Key Elements	1. "See and Avoid" 2. Clearing Procedures 3. Trust Your Instruments
Elements	1. "See and Avoid" 2. Proper Visual Scanning 3. Collision Risks 4. Clearing Procedures 5. Recognizing Hazards 6. Collision Avoidance 7. Conditions that Degrade Vision 8. Illusions
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign Next Study Material
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the importance of maintaining a vigilant scan and applies these concepts during planning and in the airplane. In the onset of an illusion the learner can recognize the illusion and maintain safe flight.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

AC 90-48C Appendix 1:

How much time do you think you would have to react if two planes were approaching each other at 360 mph from 10 miles out? 100 seconds

How about from 4 miles? 40 seconds

1 mile? 10 seconds

½ Mile? 5 seconds

What if the planes were approaching at 600 MPH? 12 seconds from 2 miles; 3 seconds from ½ mile

You can see that it's very important that we look out for other traffic.

Overview

Review Objectives and Elements/Key ideas

What

Visual scanning and collision avoidance is the knowledge and ability to recognize hazards and effectively scan the sky for potential collision threats.

Why

Safety. Visual scanning and collision avoidance is very important in creating safe skies. A diligent visual scan to avoid collision threats is paramount to the safety of all pilots.

How:

1. **"See and Avoid"** (FAR 91.113, AC 90-48) AI.II.B.K3
   - A. Flight rules prescribed in FAR part 91 set forth the concept of "See and Avoid"
   - B. The Concept
     - i. Vigilance shall be maintained at all times, by each person operating an aircraft, regardless of whether the operation is conducted under IFR or VFR
     - ii. Although the task of avoiding other aircraft is often a shared job, the pilot is always responsible to see and avoid traffic (never rely entirely on ATC for collision avoidance)
2. **Proper Visual Scanning** (AIM 8-1-6) AI.II.B.K4
   - A. Remain constantly alert to all traffic movement within the field of vision, as well as periodically scanning the entire visual field to ensure detection of conflicting traffic
   - B. Effective scanning
     - i. Only a very small area, the fovea, can send a clear, focused image to the brain (center of vision)
       - a. This is during daylight, at night, vision works differently
       - b. All other visual information not processed directly through the fovea will be of less detail
     - ii. Effective scan: short, regularly spaced eye movements bringing successive areas in the central visual field
       - a. Each movement should not exceed 10° and each area should be observed for at least 1 second
     - iii. Peripheral Vision
       - a. Can be very useful in spotting collision threats
         - Apparent movement is often detected by the peripherals
       - b. Visual search at night depends almost entirely on the peripherals
         - The fovea is very good in the daylight, but doesn't see well at night, your peripheral vision is much

better at night and thus is primary in detecting traffic in the dark

- Fovea is essentially a blind spot at night. Looking approximately 10° below, above, or to either side of an object can compensate for the fovea's inability to see at night

iv. Realize that eyes take a few seconds to refocus when switching between instruments and distant objects

C. Poor visual scanning and/or a lack of visual scanning increases the risk of midair collisions
   i. Remember, most midair collisions, and near midair collision occur during VFR weather and daylight

D. RM: Distractions to Visual Scanning AI.II.B.R1
   i. Imperative to fly based on outside references with short glances inside (90% outside, 10% inside)
      a. Allows the pilot to continue scanning
   ii. Distractions can include:
      a. Flight instruments, moving map and their numerous features, heads down activities (chart reading, checklists, cell phones, etc.), people, automation, etc.
   iii. Remove the distraction – if a person, explain the situation and ask them to stop

3. Collision Risks AI.II.B.K7

A. RM: High Traffic Areas (RM: High volume operational environments) AI.II.B.R3
   i. Airports (especially uncontrolled), VORs, VFR waypoints, VFR corridors, training areas, airways, etc.
   ii. Be especially vigilant

B. Distractions
   i. Concentrating on instruments, maps, tablet, conversation, troubleshooting a problem, or anything other than continuing the scan
   ii. Poor visibility conditions such as rain, reduced visibility/haze, and the position of the sun

C. Division of Attention AI.II.B.K8
   i. 90% outside, 10% inside
   ii. Fly with visual references to assist with scanning, verify with quick glances to the instruments

4. Clearing Procedures AI.II.B.K5

A. Before Takeoff
   i. Prior to taxiing onto the runway scan the approach area(s) for traffic

B. Climbs and Descents
   i. Execute gentle banks Left and Right at a frequency which permits continuous scanning

C. Straight and Level
   i. Execute appropriate clearing procedures at periodic intervals
   ii. Maintain a consistent scan (10° intervals focusing for at least 1 second)

D. Traffic Patterns
   i. Entries into traffic patterns while descending should be avoided
      a. Enter at pattern altitude, scanning for other traffic
      b. The aircraft blocks the view ahead of, and below the aircraft. Descending into the pattern presents the possibility of descending onto another aircraft already in the pattern

E. Traffic at VOR Sites
   i. VOR's are highly transited areas, aircraft from many different directions converge at VORs
   ii. Sustained vigilance should be maintained in the vicinity of VORs and intersections

F. Training Operations
   i. Vigilance should be maintained and clearing turns should be made prior to practicing all maneuvers
      a. Verbalize clearing procedures – "Clear Left, Right, Above, Below"

G. Blind Spots
   i. High wing and low wing aircraft have their respective blind spots
      a. Momentarily raise/lower the wing as necessary to clear for traffic before turning
   ii. Look around any blind spots created by the fuselage frame, sun visors, windshield posts, etc.

5. Recognizing Mid-Air Collisions (AC 90-48, AIM 8-1-8) AI.II.B.K6

A. RM: Aircraft Speed and Collision Reaction Time (RM: Collision reaction time) AI.II.B.R4
   i. Approaching aircraft have very high closure rates
   ii. Studies have shown that the minimum time it takes for a pilot to spot the traffic, identify it, realize it's a collision threat, react, and have the airplane respond is *at least* 12.5 seconds (table below)

Table 1. Aircraft Identification and Reaction Time Chart

Event	Seconds
See Object	0.1
Recognize Aircraft	1.0
Become Aware of Collision Course	5.0
Decision to Turn Left or Right	4.0
Muscular Reaction	0.4
Aircraft Lag Time	2.0
TOTAL	12.5

B. Recognize High Hazard Areas
   i. Aircraft tend to cluster near VORs, and Class B, C, D, and E surface areas
      a. Being in a radar environment still requires vigilance (don't depend on ATC)
C. Determining Relative Altitude
   i. Use the horizon as a general reference point
      a. If the aircraft is above the horizon, it's likely on a higher flight path
      b. If the aircraft is below the horizon, it's likely on a lower flight path
D. Collision Course Targets
   i. Any aircraft that appears to have no relative motion is likely to be on a collision course
      a. If there is no lateral or vertical motion in the windscreen, but it increases in size, take evasive action
         - Like an aiming point on approach (object remains stationary)
E. Taking Appropriate Action
   i. If on a collision course, take immediate actions
      a. Preferably in compliance with the FARS, but do what is necessary to avoid hitting the aircraft
         - Be familiar with Right-of-Way rules (FAR 91.113)
      b. Anticipate that the other pilot may make a quick maneuver as well
         - Watch the other aircraft and continue scanning as there may be other aircraft in the area

6. **Collision Avoidance** (AIM 8-1-8)
   A. Flight deck Management
      i. Studying maps, checklists, and manuals before flight, with other proper preflight planning (radio frequencies, organizing materials) can permit more time for scanning
   B. Visual obstructions in the Flight deck
      i. Move to see around blind spots caused by aircraft structures (posts, wings, etc.)
         a. Maneuver the aircraft if necessary (in the case of wings)
      ii. Do not block your view outside with maps, checklists, etc.
   C. Windshield Conditions
      i. Keep the windscreen clean, dirty or bug smeared windscreens can greatly reduce vision
         a. Dirty windscreens facing into the sun are especially difficult to see through
   D. Be More Visible
      i. Day or night, use exterior lights
      ii. Keep interior lights low at night to maintain night vision
   E. ADS-B
      i. Other traffic is displayed on the MFD, often times with visual and/or audio alerts
         a. Do not rely on ADS-B as a substitute for scanning
         b. Understand the operation, capabilities, and limitations
   F. ATC Support
      i. Use flight following for radar traffic advisories whenever possible
   G. RM: Safety Pilot/Another set of Eyes (RM: Use of a safety pilot) AI.II.B.R5
      i. Any additional help in scanning and pointing out other traffic is very beneficial to collision avoidance
7. **Environmental Conditions that Degrade Vision** (AIM 8-1-6) AI.II.B.K1

A. Physical Health and Vision
    i. Diet and physical health have an impact on how well a pilot can see, especially in the dark
    ii. Vision can be degraded by numerous physical factors, including:
        a. Medicines/drugs, exhaustion, poor physical conditioning, missing meals, alcohol, tobacco, stressors, fatigue, lack of oxygen (hypoxia), etc.
        b. Deficiencies in Vitamin A and C have been shown to reduce night acuity
    iii. Factors such as carbon monoxide poisoning, smoking, alcohol, certain drugs, and a lack of oxygen can especially decrease night vision
B. Environmental Conditions
    i. Dim illumination
        a. Small print and colors become unreadable unless adequate lighting is available
            - Aeronautical charts, instruments, notes, etc. become hard to read
    ii. Darkness
        a. Dark Adaptation - Vision becomes more sensitive to light
            - Exposure to darkness for at least 30 minutes is required for complete dark adaptation
            - Night vision is impaired by:
                a Exposure to cabin pressure altitudes above 5,000'
                b Carbon monoxide inhaled in smoking and from exhaust fumes
                c Deficiency of Vitamin A in the diet
                d Prolonged exposure to bright sunlight
            - Since any degree of dark adaptation is lost within a few seconds of viewing a bright light, a pilot should close one eye when using light to preserve some degree of night vision
    iii. Excessive Illumination
        a. Examples: Light reflected off the canopy, surfaces in the aircraft, clouds, water, snow, desert terrain
            - These can produce glare, uncontrollable squinting, eye watering, even temporary blindness
            - Fly with sunglasses or some sort of shading device as much as possible
    iv. Visibility Conditions
        a. Smoke, haze, dust, rain, and flying toward the sun can reduce the ability to see other aircraft
    v. RM: Relaxed Intermediate Focal Distance AI.II.B.R2
        a. With nothing to focus on the eyes focus on a point slightly ahead of the plane (10-30')
            - Induced nearsightedness resulting in poor scanning
            - Example: Hazy skies without a clear horizon or reference
        b. Preventing
            - To be most effective, shift glances and refocus at intervals
            - Day: Recognize the issue and force your eyes to focus farther ahead, maintain your scan
            - Night: Search out and focus on distant light sources, no matter how dim

8. Vestibular / In Flight / Visual Illusions AI.II.B.K2

A. Preventing Spatial Disorientation
    i. Can only be prevented by visual reference to reliable, fixed points on the ground, or to flight instruments
        a. Trust your instruments when disoriented!
B. The Leans
    i. Reason
        a. An abrupt correction of a banked attitude entered too slowly to stimulate the motion sensing system in the inner ear
    ii. Illusion
        a. Can create the illusion of banking in the opposite direction
    iii. Result

a. The disoriented pilot will roll the aircraft back into its original dangerous attitude (the turn), thinking (feeling) the airplane is straight and level
b. Or will feel compelled to lean to the perceived vertical plane until the illusion subsides

C. Coriolis Illusion
  i. Reason
    a. An abrupt head movement in a prolonged constant rate turn that has ceased to stimulate the brain's motion sensing system
  ii. Illusion
    a. Can create the illusion of rotation or movement in an entirely different axis
  iii. Result
    a. The disoriented pilot may maneuver the aircraft into a dangerous attitude to stop the perceived rotation
  iv. Prevention
    a. Don't make sudden, extreme head movements, particularly while making prolonged constant rate turns under IFR conditions
    b. Develop an instrument cross-check that involves minimal head movement
    c. If something is dropped, use minimal head movement and be alert for the Coriolis illusion
D. Graveyard Spin
  i. Reason
    a. Recovery from a spin that has ceased stimulating the motion sensing system
  ii. Illusion
    a. Can create the illusion of being in a spin in the opposite direction
  iii. Result
    a. The disoriented pilot will return the aircraft to its original spin
E. Graveyard Spiral
  i. Reason
    a. There is an observed loss of altitude during a prolonged constant rate turn which has ceased to stimulate the motion sensing system
  ii. Illusion
    a. Can create the illusion of a wings level descent
  iii. Result
    a. The disoriented pilot will pull back on the controls, tightening the spiral and increasing the loss of altitude
F. Somatogravic Illusion
  i. Reason
    a. A rapid acceleration, often during takeoff
  ii. Illusion
    a. In the case of a rapid acceleration, it can create the illusion of being in a nose up attitude
    b. In the case of a rapid deceleration, it can create the illusion of being in a nose down attitude
  iii. Result
    a. The disoriented pilot will put the aircraft in a nose low, or dive attitude
    b. The disoriented pilot will put the aircraft in a nose up, or stall attitude
G. Inversion Illusion
  i. Reason
    a. An abrupt change from a climb to straight and level flight
  ii. Illusion
    a. Can create the illusion of tumbling backwards
  iii. Result
    a. The disoriented pilot will push the aircraft abruptly into a nose low attitude

- This could intensify the situation

H. Elevator Illusion
   i. Reason
      a. An abrupt upward vertical acceleration, usually due to an updraft
      b. An abrupt downward vertical acceleration, usually due to a down draft
   ii. Illusion
      a. Upward vertical acceleration can create the illusion of being in a climb
      b. Downward vertical acceleration can create the illusion of being in a descent
   iii. Result
      a. The disoriented pilot will push the aircraft into a nose low attitude
      b. The disoriented pilot will pull the aircraft into a nose up attitude

I. False Horizon
   i. Reason
      a. Sloping cloud formations, an obscured horizon, a dark scene spread with ground lights and stars, and certain geometric patterns of ground light
   ii. Illusions
      a. Can create the illusion of not being aligned correctly with the horizon
   iii. Result
      a. The disoriented pilot will put the aircraft in a dangerous attitude

J. Autokinesis
   i. Reason
      a. In the dark
   ii. Illusion
      a. A static light when stared at for many seconds will appear to move about
   iii. Result
      a. The disoriented pilot will lose control of the aircraft in attempting to align it with the light

Conclusion:
Brief review of the main points
Maintaining proper, efficient visual scanning and keeping an eye out for traffic is very important. Also, in the case of illusions, it is extremely important we understand when and where they may happen and how to best prevent them from getting us into a dangerous situation. Finally, CFIT is an issue affecting all GA pilots. Planning ahead, maintaining situational awareness, and adjusting to changing conditions are the best tools to combat CFIT (and, of course, a GPWS system).

II.C. Runway Incursion Avoidance

References:
Single Pilot Flight School Procedures During Taxi Operations (AC 91-73)
AIM – Chapter 4-3-18 Taxiing
Airplane Flying Handbook (FAA-H-8083-3) – Chapter 1 pgs. 12-13
Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25) – Chapter 14 pgs. 31-33
Risk Management Handbook (FAA-H-8083-2)

Objectives	The learner develops and understands techniques for effective incursion avoidance.
Key Elements	1. Read back all clearances 2. Head down activities only when stopped 3. Always have current Airport Diagram (AD)
Elements	1. Runway Incursion 2. Taxi Instructions 3. Plan, Brief, and Review 4. Appropriate Flight Deck Activities 5. Airport Markings, Signs, & Lights 6. Airport Operations & Runway Incursions 7. Case Study: United 1448
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can safely and competently navigate towered and non-towered airports while effectively avoiding runway incursions.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Runway incursions have led to serious accidents with significant loss of life… (YouTube has many runway incursion recordings, incorrect taxi instructions, aircraft taxiing the wrong way, etc.)

Overview

Review Objectives and Elements/Key ideas

What

Runway incursion avoidance provides practical guidance with the goal of increasing safety and efficiency of aircraft movement on the airport surface while reducing the risk of runway incursions.

Why

Runway incursions have sometimes led to serious accidents with significant loss of aircraft as well as life. Although they are not a new problem, with increasing air traffic, runway incursions have been on the rise.

How:

1. **Runway Incursion** AI.II.C.K1
   - A. Any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of separation with an aircraft taking off, landing, or intending to land
   - B. Approximately 3 runway incursions occur each day at towered airports in the US
     - i. About 65% of all incursions are caused by pilots (about half are caused by GA pilots)
     - ii. Pilot Deviation examples: Crossing a runway without a clearance, takeoff or landing without a clearance
   - C. Airport/Taxiing Challenges
     - i. Situational Awareness
       - a. Increased traffic and airport expansion creates complex runway and taxiway layouts
       - b. Surface operations are more difficult & the potential for incursions are more hazardous than before
     - ii. Distractions
       - a. Checklists, radio calls, cell phone (texting, phone calls, etc.)
     - iii. With increasing air traffic, runway incursions have been on the rise
       - a. One of the biggest safety concerns in aviation is the surface movement accident
   - D. Causal Factors
     - i. Failure to comply with ATC instructions
     - ii. Lack of airport familiarity
     - iii. Nonconformance with standard operating procedures (SOPs)
   - E. Preventive Practices
     - i. Be aware of the airplane's position and be aware of other aircraft and vehicle operations on the airport
       - a. Listen to other radio calls and build a 3D picture of other traffic on the airport surface area
     - ii. Readback all runway crossing and/or hold short instructions
     - iii. Review airport layouts
     - iv. Know airport signage
     - v. Review NOTAMs
     - vi. Request progressive taxi instructions when necessary
     - vii. Check for traffic before crossing any runway hold line or entering any taxiway

viii. Turn on lights and the rotating beacon or strobes when taxiing
ix. When landing, clear the runway as soon as possible and wait for taxi instructions before moving
x. Study & use proper phraseology
xi. Write down complex taxi instructions

2. Taxi Instructions & Clearances AI.II.C.K2

A. Approval must be obtained prior to moving onto the movement area while tower is in operation
B. Clearance must be obtained prior to crossing ***any runway***
  i. Any runway means ***any runway***: active, inactive, open, closed, etc.
C. When assigned taxi instructions, ATC will specify:
  i. The runway or the point to taxi to
  ii. Taxi instructions
  iii. Hold short instructions or runway crossing clearances if the route will cross a runway
    a. This does not authorize the aircraft to enter or cross the assigned departure runway at any point
D. When instructions are received from the controller, always read back:
  i. The runway assignment
  ii. RM: Any clearance to enter a specific runway (RM: Entering or crossing runways) AI.II.C.R3
  iii. Any instruction to hold short of a specific runway
E. Uncontrolled Field AI.II.C.K6
  i. Announce your intentions on CTAF
    a. Always have a taxi diagram – Review and plan your route
  ii. Monitor CTAF to be aware of other aircraft on/around the airport
    a. Build a mental picture of their location in relation to you
    b. Departing or arriving? Will they be crossing your planned taxi route?
  iii. Apply the right-of-way rules, and give way when appropriate, or when safety dictates
  iv. Radio communication is not required at uncontrolled fields, therefore a visual scan is very important

3. Plan, Brief, and Review

A. Route Planning
  i. Have a current copy of the Airport Diagram
  ii. Large airports often have pre-designated, or standard, taxi routes, review these for familiarity
    a. Used to reduce frequency congestion and streamline taxi procedures
  iii. Based on the runway in use and usable taxiways, review the expected routes
B. Taxi Briefing (AC 91-73)
  i. Taxi operations briefings should include the following (prior to taxi, and prior to landing)
    a. Ground Procedures
      - Timing and execution of checklists/communications that will not interfere with taxiing
      - Expected route/any abnormalities or unusual procedures
      - Identify critical locations on the taxi route (hold short, hot spots, etc.)
      - Address previous experience/unusual procedures or techniques
      - During low visibility operations, brief the requirements and considerations
    b. Expectations of others (pilots of passengers) in the plane
      - Sterile flight deck procedures - encourage others to speak up if they see a potential conflict
      - Use of airport diagrams (pilots)
      - Cell phones/electronic devices should be off
C. Record & Review AI.II.C.K3
  i. Always write down ATC taxi instructions to prevent mistakes
    a. Helps ensure you follow ATC's instruction, rather than what you expected or planned
  ii. Review the route given by ATC, ask for help in case of confusion

a. Ensures you understand where to go, increases situational awareness and prevents disorientation
b. Progressive Taxi
   - If unfamiliar with the airport or confusion exits, you can request progressive taxi instructions
   - Step-by-step routing directions
c. Be aware of hold short lines and ILS critical areas (if in use) on your route of taxi
   - Without explicit clearance, do not cross either of these (only required if ILS critical areas are in use)

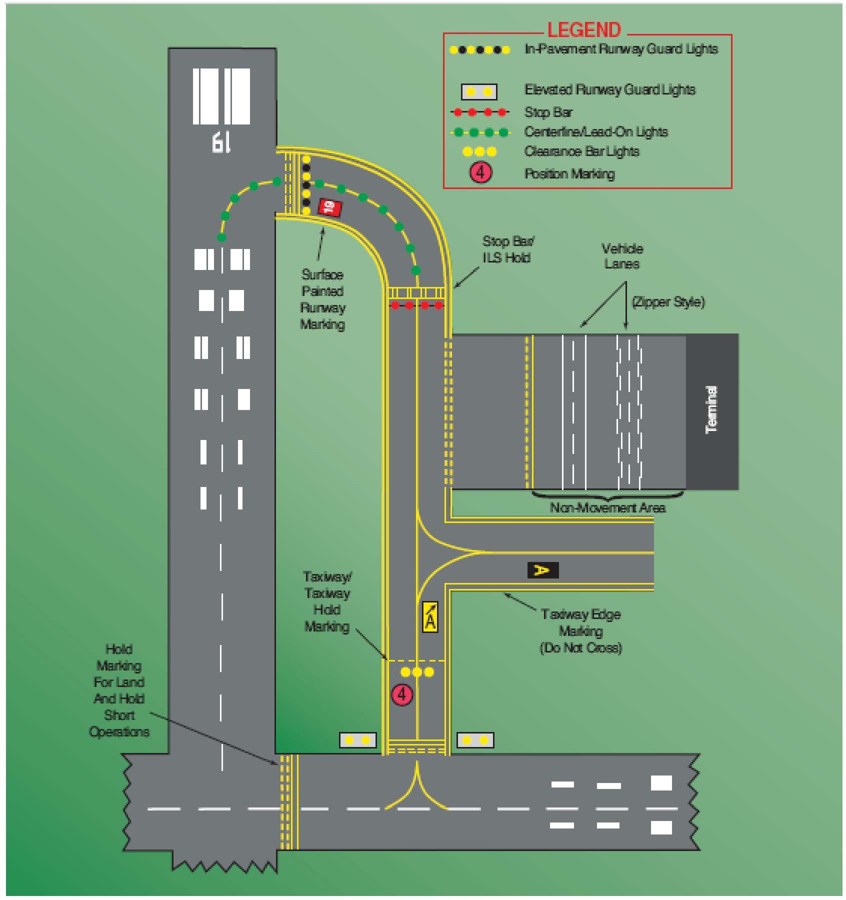
iii. Benefits
a. Recording taxi instructions
   - Prevents mistakes and forgetfulness
   - RM: Combats confirmation/expectation bias AI.II.C.R2
     a Expectation Bias: Your expectations can influence behavior
     b Individuals are vulnerable to thinking they see (or hear) what they expect to see (or hear)
       1. Ex: You always taxi C, D to runway 27, so when ground clears you a different route (C, F, B, D), out of habit/expectation you hear what you expect to hear (C, D) and taxi the wrong way
   - Verifies what you heard is what the controller said
b. Reviewing the taxi instructions & route
   - Increases situational awareness
   - Allows the pilot to recognize any confusion/questions prior to moving
   - Allows the pilot to operate with their head up/eyes outside to the max extent

4. RM: **Appropriate Flightdeck Activities** (RM: Distractions, Task Prioritization) AI.II.C.K5, AI.II.C.R1

A. For safety reasons the pilot's workload should be at a minimum during taxi operations
   i. This can be accomplished through SOPs that direct attention only to essential tasks while taxiing
   ii. Complete pre-taxi checklists and data entry *prior* to taxi
   iii. All heads down activities should be done only when the aircraft is stopped
   iv. RM: Task prioritization – taxiing comes first, handle all other tasks when safely stopped
B. A sterile flight deck should be implemented from taxi through climb to focus on taxiing/ATC instruction
   i. No cell phones, conversations, or anything unnecessary to the duties of flight
   ii. Remove distractions from view – if it's a person, explain the situation and ask them to stop
C. Taxiing Near Other Aircraft
   i. Use a "continuous loop" process to monitor and update their progress and location
      a. Know your present location and mentally calculate the next location that will require increased attention (crossing traffic, hot spot, etc.)
   ii. Awareness is enhanced by understanding the clearance issued to pilots, other aircraft, and vehicles
      a. Listen to other aircraft on the radio and the instruction they are given, develop a picture of other aircraft in relation to you, maintain situational awareness!
      b. Don't set expectations, listen to, and comply with, the clearance(s) you receive
   iii. Be especially vigilant if another aircraft with a similar call sign is on frequency
      a. Care should be taken to avoid inadvertently executing a clearance for another aircraft
      b. Ask if you're unsure of who the radio call was for

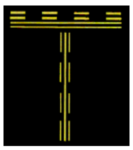
5. Airport Markings, Signs, & Lights AI.II.C.K4

A. Taxiway Markings
   i. General
      a. Taxiways should have centerline/runway holding position markings whenever intersecting a runway
      b. Edge markings delineate areas not for aircraft use or define taxiway edges
      c. May have shoulder/hold position markings for ILS critical areas and taxiways/taxiway intersections
   ii. Taxiway Centerline Markings



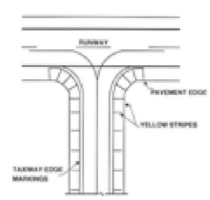
a. Normal Centerline
- Purpose - Provide a visual cue to permit taxiing along a designated path
- Markings - A single continuous yellow line that is 6” - 12” wide

b. Enhanced Centerline



- Purpose - Same as above but at larger commercial airports to warn that a runway hold position marking is being approached and unless cleared to cross, the aircraft should prepare to stop
- Markings - A parallel line of yellow dashes on either side of the normal taxiway centerline
    - a Centerlines are enhanced for a max of 150’ prior to a runway holding position marking

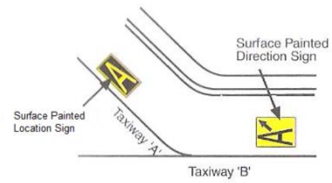
iii. Taxiway Edge Markings
  a. Purpose - Defines the edge of the taxiway (usually when edge doesn’t match up with pavement)
  b. 2 types of markings, depending on whether the aircraft is supposed to cross the taxiway edge
  - Continuous Markings
    - a Purpose - Define the taxiway edge from the shoulder/paved surface not for use by aircraft
    - b Markings - Continuous double yellow line with each line at least 6’’ wide and 6’’ apart
  - Dashed Markings
    - a Purpose - Define the taxiway edge when adjoining pavement is intended for aircraft (Apron)
    - b Markings - Broken double yellow line (6” wide, spaced 6” apart; dashes are 15’ long and 25’ apart)



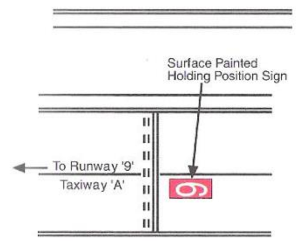
iv. Taxi Shoulder Markings
  a. Purpose - Paved shoulders prevent erosion but they may not support aircraft
  b. Markings - Taxiway edge markings will usually define this area
  - If confusion exists to the side of use, yellow shoulder markings are used

v. Surface Painted Taxiway Direction Signs
  a. Purpose - When it isn’t possible to offer direction signs at intersections, or to supplement such signs
  b. Markings - Surface painted location signs with a yellow background and black inscription

- Adjacent to the centerline with signs indicating left turns on the left side of the centerline and vice versa



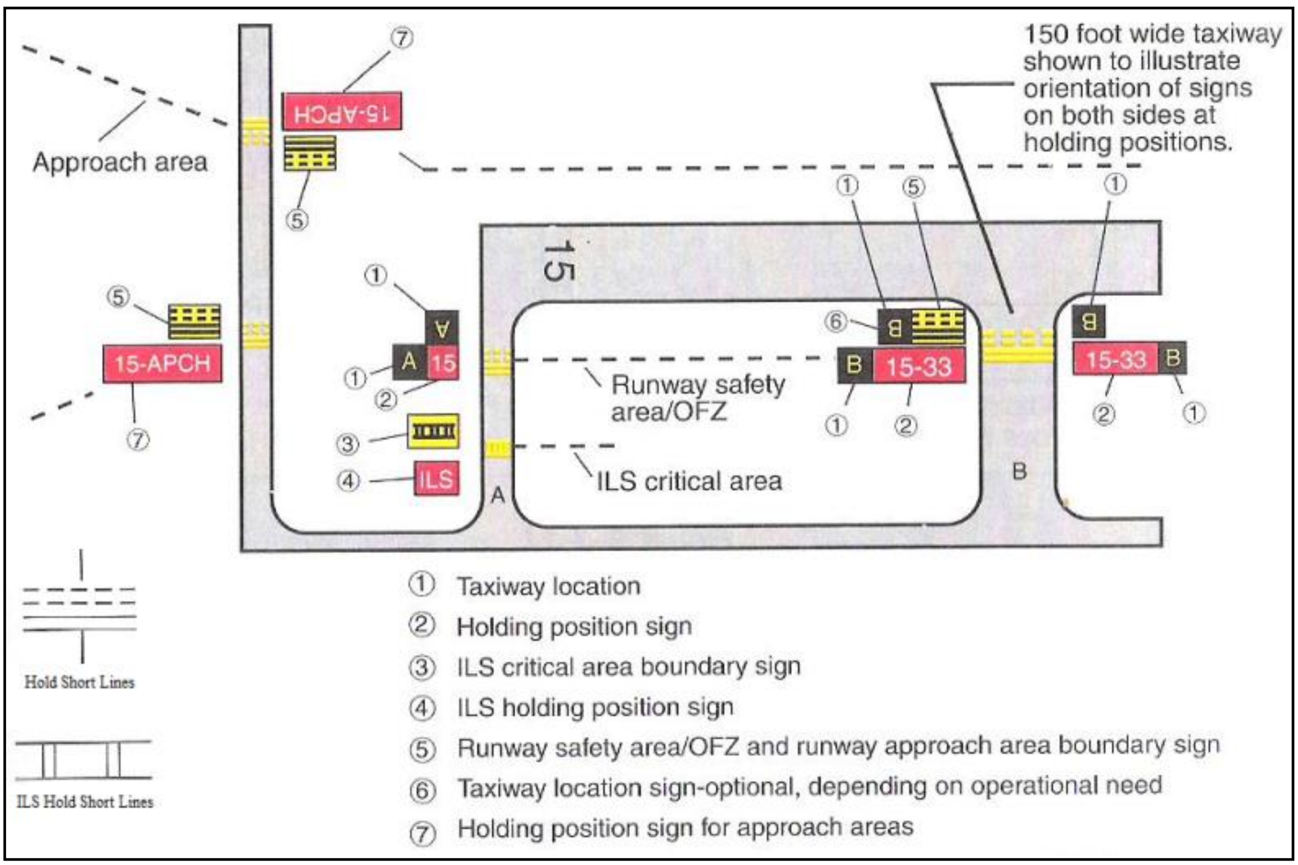
vi. Surface Painted Location Signs
   a. Purpose - Supplement location signs alongside the taxiway assisting in confirming the taxiway one is on
   b. Markings - Black background with a yellow inscription, right of center



vii. Geographic Position Markings
   a. Purpose - Identifies aircraft location during low visibility operations
   b. Markings - Left of the taxiway centerline in the direction of taxiing

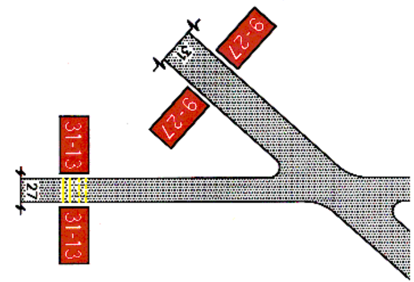
- A circle with an outer black ring, inner white ring and a pink circle
   - a When on dark pavements the white/black ring are reversed
- Designated with either a number or a number and a letter
   - a Number corresponds with consecutive position on the route

B. Holding Position Markings

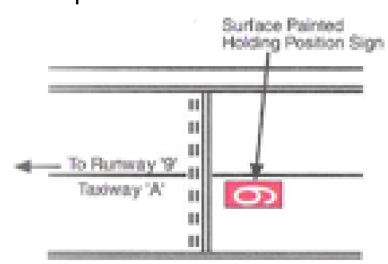


i. General
   a. Show where an aircraft is supposed to stop when approaching a runway (hold on the solid side)
   b. 4 yellow lines (2 Solid/2 Dashed) spaced 6" or 12" apart across the width of the taxiway or runway
      - 3 locations where runway hold lines are encountered: Taxiways, Runways. Approach Areas

- ii. Runway Holding Position Markings on Taxiways
  - a. Purpose - Identify where to stop without a clearance onto the runway
    - Always stop so that no part extends beyond the hold markers
    - Don't cross without clearance and separation at uncontrolled airports
- iii. Runway Holding Position Markings on Runways (as shown to the right)
  - a. Purpose - installed if normally used for LAHSO or taxiing operations
    - Must stop before markings/exit prior to reaching the position
  - b. Markings - Sign (white inscription/red background) next to hold markings
    - Markings are placed on the runway prior to the intersection

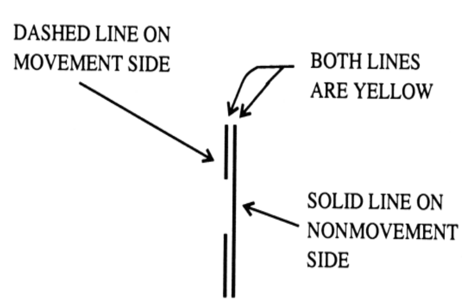


- iv. Taxiways Located in Runway Approach Area
  - a. Purpose - Hold aircraft on a taxiway so it doesn't interfere with operations
  - b. Holding Position Markings for Instrument Landing System (ILS)
    - Purpose - Hold aircraft when the ILS critical area is being protected
    - Markings - 2 yellow solid lines 2' apart joined by pairs of solid lines 10' apart across the taxiway
  - c. Holding Position Markings for Taxiway/Taxiway Intersections
    - Purpose - Installed on taxiways where ATC normally holds aircraft short of a taxiway intersection
    - Markings - Single dashed line extending across the width of the taxiway
      - a If requested to hold short of a taxiway without markings, provide adequate clearance from the taxiway
  - d. Surface Painted Holding Position Signs (as shown to the right)
    - Purpose - Supplements the signs located at the holding position
      - a Normally used when the width of the holding position on the taxiway is greater than 200'
    - Markings - Red background/white inscription, left of center, on the holding side, prior to hold lines



C. Other Markings

- i. Vehicle Roadway Markings
  - a. Purpose - Used to define a path for vehicle operations on or crossing areas also intended for aircraft
  - b. Markings - White solid line delineates each edge and a dashed line separates lanes
    - In lieu of the solid lines, zipper markings may be used to delineate edges
- ii. VOR Receiver Checkpoint Markings
  - a. Purpose - Allow the pilot to check aircraft instruments with navigational aid signals
  - b. Markings - A painted circle with an arrow in the middle (arrow is aligned toward the facility)
    - Located with a sign on the apron/taxiway
    - Sign shows the VOR station ID letter, course for the check, and DME data (if necessary)
    - Black letters/numerals on a yellow background
- iii. Nonmovement Area Boundary Markings (as shown on the right)
  - a. Purpose - Delineates the movement area (The area under air traffic control)
  - b. Markings - 2 yellow lines (one solid and one dashed) 6" in width
    - Solid line is the nonmovement area side, the dashed line is the movement area side



- iv. Marking and Lighting of Permanently Closed Runways

a. Purpose - For runways and taxiways which are permanently closed
b. Markings - The lighting circuits will be disconnected
- The runway threshold, designation, and touchdown markings are obliterated
- Yellow crosses are placed at each end of the runway and at 1,000’ intervals

v. Temporarily Closed Runways and Taxiways
a. Purpose - To provide a visual indication to pilots that a runway is temporarily closed
b. Markings - Yellow crosses are placed on the runway at each end
- A raised lighted yellow cross may be placed on each end of the runway instead
- A visual indication may not be present depending on the reason for closure, duration of the closure, configuration and the existence and hours of operation of an airport control tower
  - a Check NOTAMs and the ATIS for information
- Closed taxiways are treated as hazardous areas and blockaded; no part of the aircraft may enter
  - a As an alternative, a yellow cross may be installed at each entrance to the taxiway

D. Runway Markings (discuss as required for incursion avoidance; intent was to keep all airport markings together)
i. There are three types of markings for runways:
a. Visual; Nonprecision Instrument; Precision Instrument
b. Diagram Notes
- Note 1: Required on runways serving category C/D aircraft, & international commercial transport
- Note 2: Required on 4,200’ or longer runways serving categories C & D airplanes
- Note 3: Required on 4,200’ or longer instrumented runways
- Note 4: Used when the full runway pavement width may not be available for use as a runway

ii. Runway Designators
a. Purpose - To identify / differentiate runways from the approach end
- To Magnetic North; whole number to the nearest one-tenth of the runway course
- L, R, C differentiate multiple parallel runways

b. Markings - Large white numbers

iii. Runway Centerline Marking
a. Purpose - Identifies the center of the runway providing alignment guidance
b. Markings - A line of uniformly spaced stripes and gaps

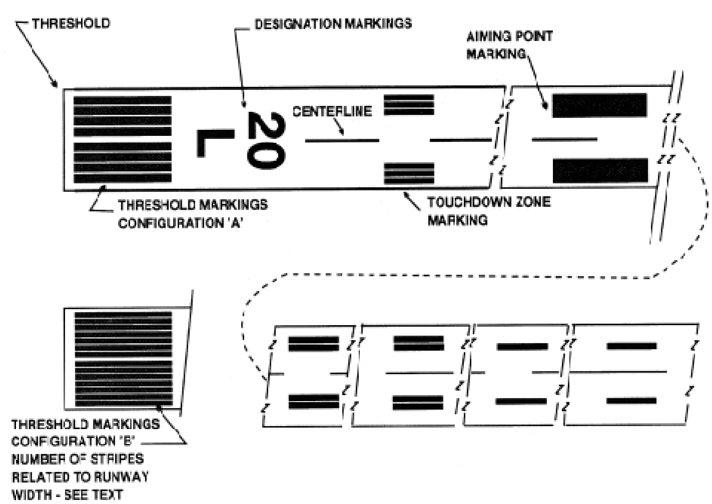
iv. Runway Aiming Point Markings
a. Purpose - Serves as a visual aiming point for a landing aircraft
b. Markings - Broad white stripe on each side of the centerline, approximately 1,000’ from threshold

v. Runway Touchdown Zone Markers
a. Purpose - Identifies touchdown zone for landing; provide distance info in 500’ increments
b. Markings - Groups of 1, 2, and 3 rectangular bars in pairs about the runway centerline

vi. Runway Side Stripe Markings
a. Purpose - Delineate edges of the runway providing a contrast between the runway and shoulder
b. Markings - Continuous white stripes

Runway Surface Marking Scheme	Threshold Approach Category		
	Visual Approach	Non-precision Approach (Approaches with vertical guidance not lower than 0.75 statute mile visibility)	Precision Approach (Approaches with vertical guidance lower than 0.75 statute mile visibility)
Runway diagram			
Landing Designator	Required	Required	Required
Centerline	Required	Required	Required
Threshold	Note 1	Required	Required
Aiming Point	Note 2	Note 3	Required
Touchdown Zone	(not applicable)	(not applicable)	Required
Edge Markings	Note 4	Note 4	Required

Precision Instrument Runway Markings



located on each side of the runway

vii. Runway Shoulder Markings
  a. Purpose - Identify pavement areas not intended for aircraft use
  b. Markings - Yellow stripes

viii. Runway Threshold Markings (stripes vary with width, chart to right)
  a. Purpose - Identifies beginning of the runway available for landing
  b. Markings - Stripes about the centerline
  c. Displaced Threshold (DT)
    - Explanation
      a Landing threshold starts at a point other than the beginning of the runway
      b Used for taxiing, takeoff, landing rollout (not to be landed on, reduces landing distance)

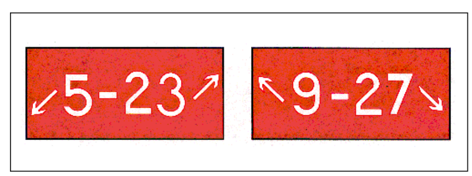
Runway Width	Stripes
60 feet	4
75 feet	6
100 feet	8
150 feet	12
200 feet	16

    - Markings
      a A 10’ wide white threshold bar across the runway at the displaced threshold
      b White arrow heads are located across the runway just prior to the threshold bar
      c White arrows down the centerline between the start of the runway and displaced threshold
    - Relocated Threshold
      a Explanation – Construction / other activities require the threshold to be relocated (NOTAM)
      b Markings – Normally a 10’ wide white threshold bar across the runway, but can vary

E. Airport Signs

i. General
  a. Six types of signs installed on airfields
    - Mandatory Instruction; Location; Direction; Destination; Information; Runway Distance Remaining

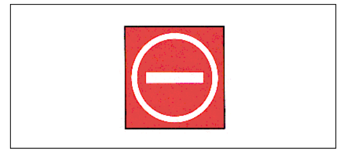
ii. Mandatory Instruction Signs
  a. Purpose - Denote entrance to runway or critical area/area where aircraft are prohibited
  b. Markings - Red background with a white inscription
  c. Typical Mandatory Signs and Applications



    - Runway Holding Position Sign
      a Located at the hold position on taxiways intersecting runways/runways intersecting runways
      b The sign states the designation of the intersecting runway
    - Runway Approach Area Holding Position Sign
      a Used when necessary to hold aircraft on a taxiway in a runway approach/departure area so it doesn’t interfere with runway ops

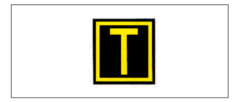
    - ILS Critical Area Holding Position Sign
      a ILS system is being used, and it’s necessary to hold at a location other than the Hold Markers
      b The sign will have the inscription “ILS” and will be located adjacent to the holding position marking on the taxiway

- No Entry Sign
    - a Prohibits an aircraft from entering an area
    - b Typically, on a taxiway intended to operate in one direction or vehicle intersections that may be mistaken as a taxiway/movement surface



iii. Location Signs
  a. Purpose - Identify either a taxiway or runway on which the aircraft is located
    - Other location signs provide a visual cue to assist in determining when an area has been exited

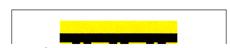
  b. Taxiway Location Sign
    - Purpose - Along taxiways to indicate location
    - Markings - Black background with yellow inscription and border

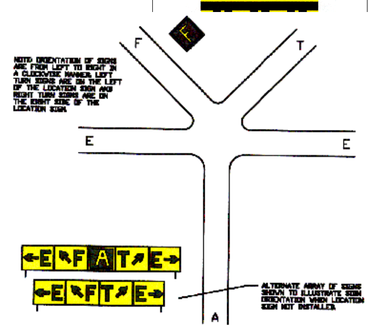


  c. Runway Location Sign
    - Purpose - Complement compass info; typically installed where the proximity of runways to one another could cause confusion as to which runway the pilot is on
    - Markings - Black background with a yellow inscription

  d. Runway Boundary Sign
    - Purpose - Provides a visual cue to use as a guide in deciding when "clear of the runway"
        - a Adjacent to the hold markings on the pavement
        - b Visible when exiting the runway
    - Markings - Yellow background/black inscription depicting the hold markings

  e. ILS Critical Area Boundary Sign
    - Purpose - Provides a visual cue to use as a guide in deciding when clear of the ILS critical area
        - a Adjacent to ILS hold markings and can be seen leaving the critical area
    - Markings - Yellow background/black inscription depicting ILS hold markings



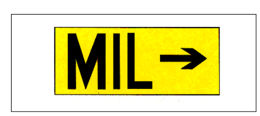


iv. Direction Signs
  a. Purpose - Identify intersecting taxiways leading out of an intersection
        - a Designations and their arrows are arranged clockwise from the 1st taxiway on the pilot's left

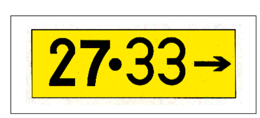
  b. Markings - Yellow background/black inscription with an arrow indicating the turn direction

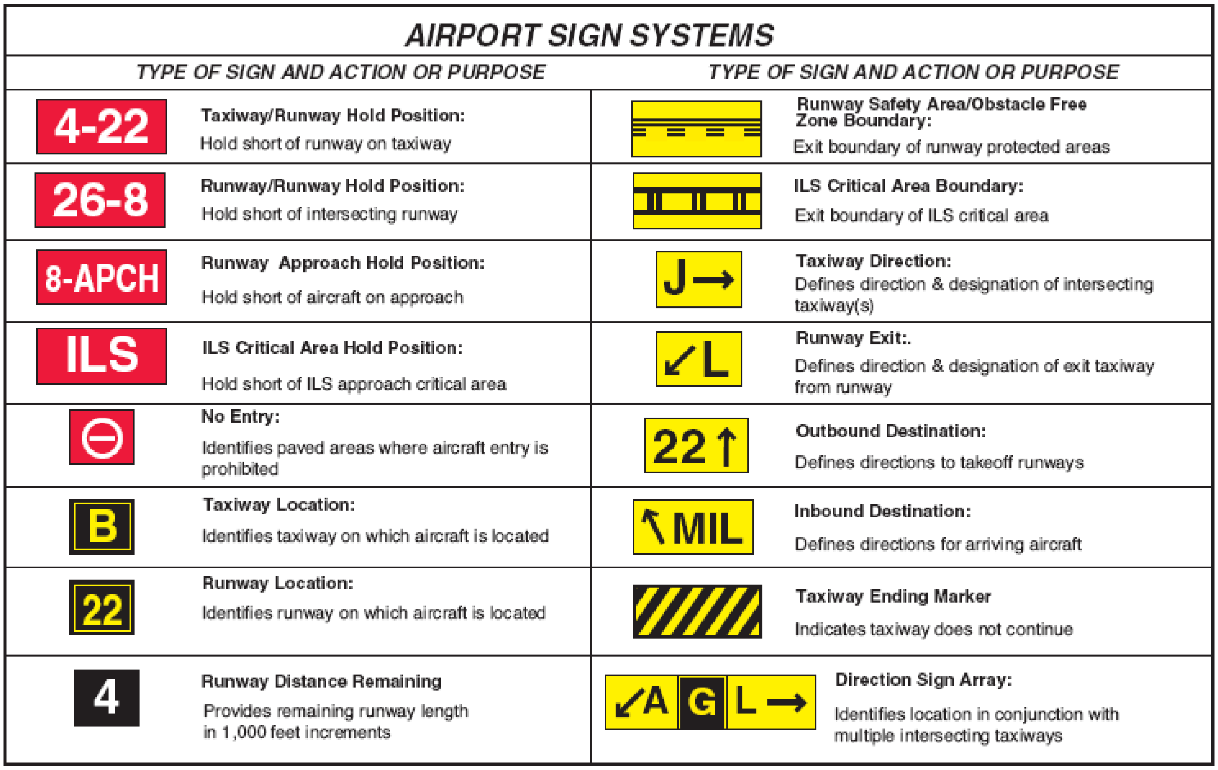
v. Destination Signs
  a. Purpose - Indicates a destination on the airport
    - Destinations commonly shown are
        - Runways
        - Aprons
        - Terminals
        - Military Areas
        - Civil Aviation Areas
        - Cargo Areas
        - International Areas
        - FBOs

  b. Markings - Yellow background/black inscription indicating a destination
    - Always have an arrow showing the direction of the taxiing route to that destination sign



vi. Information Signs
  a. Purpose - Used to provide a pilot with information on things such as:
    - Areas the tower can't see, radio frequencies, and noise abatement procedures





AIRPORT SIGN SYSTEMS

Sign	TYPE OF SIGN AND ACTION OR PURPOSE	Sign	TYPE OF SIGN AND ACTION OR PURPOSE
4-22	**Taxiway/Runway Hold Position:** Hold short of runway on taxiway		**Runway Safety Area/Obstacle Free Zone Boundary:** Exit boundary of runway protected areas
26-8	**Runway/Runway Hold Position:** Hold short of intersecting runway		**ILS Critical Area Boundary:** Exit boundary of ILS critical area
8-APCH	**Runway Approach Hold Position:** Hold short of aircraft on approach	J→	**Taxiway Direction:** Defines direction & designation of intersecting taxiway(s)
ILS	**ILS Critical Area Hold Position:** Hold short of ILS approach critical area	↙L	**Runway Exit:.** Defines direction & designation of exit taxiway from runway
⊖	**No Entry:** Identifies paved areas where aircraft entry is prohibited	22↑	**Outbound Destination:** Defines directions to takeoff runways
B	**Taxiway Location:** Identifies taxiway on which aircraft is located	↖MIL	**Inbound Destination:** Defines directions for arriving aircraft
22	**Runway Location:** Identifies runway on which aircraft is located		**Taxiway Ending Marker** Indicates taxiway does not continue
4	**Runway Distance Remaining** Provides remaining runway length in 1,000 feet increments	↙A G L→	**Direction Sign Array:** Identifies location in conjunction with multiple intersecting taxiways

b. Markings - Yellow Background with a black inscription

vii. Runway Distance Remaining Signs

a. Purpose - Inform the pilot the distance remaining on the runway
- Thousands of feet of landing runway remaining

viii. Markings – Black background with white numeral inscription

F. Airport Lighting

i. Taxiway Lighting

a. Taxiway Edge Lights
- Steady blue lights outlining the edges of taxiways

b. Taxiway Centerline lights
- Steady green lights installed along the centerline of the taxiway

c. Clearance Bar Lights
- Three in-pavement steady-burning yellow lights
- Installed at holding positions on taxiways to increase visibility of the holding position

d. Runway Guard Lights
- Pair of elevated flashing yellow lights on either side of the taxiway, or a row of in-pavement yellow lights across the entire taxiway at the runway holding position marking
- Installed at taxiway/runway intersections
- Enhance conspicuity of taxiway/runway intersections

e. Stop Bar Lights
- A row of red, unidirectional, steady-burning in-pavement lights across the entire taxiway at the runway holding position, and elevated steady-burning red lights on each side
- A controlled stop bar operates in conjunction with the taxiway centerline lead-on lights
  - a Following ATC clearance, the stop bar is turned off and the lead-on lights are turned on
- Used to confirm the ATC clearance to enter or cross the active runway in low visibility

ii. Runway Lighting

a. Runway End Identifier Lights (REIL)
   - Installed to provide rapid / positive identification of the approach end of a runway
   - Configuration - Pair of synchronized flashing lights on each side of the runway threshold

b. Runway Edge Light Systems (HIRL, MIRL, LIRL)
   - Outline the edges of runways during dark / restricted visibility conditions
     - a Classified according to the intensity or brightness: High (HIRL); Medium (MIRL); Low (LIRL)
   - Configuration
     - a Runway edge lights - White
       1. Instrument runways – Yellow for the last 2,000,’ or half the runway, whichever is shorter
     - b Lights marking the end of the runway – Red / Green
       1. Red indicates the end of the runway to a departing aircraft
       2. Green indicates the threshold to landing aircraft

c. Runway Centerline Lighting System (RCLS)
   - Installed on some precision runways to facilitate landing under adverse conditions
   - Configuration
     - a Along runway centerline at 50’ intervals
     - b From the threshold, the lights are white until the last 3,000’ of the runway
       1. White lights alternate with red for 2,000’, and the last 1,000’ all lights are red

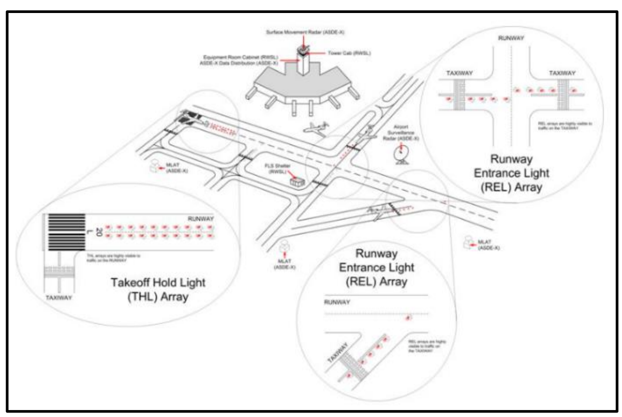
d. Touchdown Zone Lights (TDZL)
   - On some precision runways to indicate touchdown zone in low visibility conditions
   - Configuration
     - a Rows of (usually 3) lights on both sides of the runway centerline
     - b Rows begin 100’ beyond the landing threshold and extend to 3,000’ beyond the landing threshold or the midpoint of the runway, whichever is less

e. Taxiway Centerline Lead-Off Lights
   - Provide visual guidance to exit the runway
   - Configuration
     - a Alternate green & yellow lights, beginning with green, from the runway centerline to 1 light position beyond the runway hold position/ILS critical area hold position

f. Taxiway Centerline Lead-on Lights
   - Provide visual guidance for entering the runway
   - Configuration
     - a Color coded with the same pattern as lead-off lights
     - b Bidirectional (1 side emits light for the lead-on function the other for the lead-off)

g. Land and Hold Short Lights
   - Used to indicate the hold short point on certain runways approved for LAHSO
     - a When installed, the lights will be on anytime LAHSO is in effect and off when not
   - Configuration - A row of pulsing white lights installed across the runway

h. Runway Status Lights (RWSL)
   - Fully automated system providing indication it’s unsafe to enter, cross, takeoff, or land on a runway
     - a Installed at several major US airports
     - b Processes information from surveillance



systems to turn red warning lights on/off
    c Used in conjunction with ATC – lights and ATC instructions must agree
- Runway Entrance Lights (REL)
    a In-pavement red lights
    b Warns aircraft waiting to cross/enter a runway that there is conflicting traffic
- Takeoff Hold Lights (THL)
    a In-pavement red lights
    b Warns aircraft in the takeoff position that the runway is occupied & takeoff is unsafe
- More details: FAA Runway Status Lights

6. Airport Operations & Runway Incursions

A. Hold Lines
  i. Indicate where an aircraft is supposed to stop when approaching a runway
  ii. Unauthorized crossing of hold lines could result in an incursion with an aircraft taking off or landing
  iii. RM: During taxi: (RM: Entering or crossing runways) AI.II.C.R3
    a. Approaching from the dashed side, cross (no clearance necessary) and stop fully passed the solid lines
    b. If approaching hold lines from the solid side, do not cross without a clearance
      - If you arrive at hold short lines without a clearance (or are unsure), stop and request clearance
    c. Always clear both directions before crossing
    d. Turn on all exterior lights whenever taxiing on/across a runway

B. RM: Landing and Rollout AI.II.C.R6, AI.II.C.R7
(RM: Runway incursion after landing & Operating on taxiways between runways)
  i. When landing and rolling out on a taxiway that will cross/approach another runway, brief the situation
    a. Know where you will stop, what taxiways are appropriate to use/not use, and potential hot spots
    b. Taxi slow, don't exit at high speeds
  ii. RM: After landing, ensure that the entire aircraft has crossed over the hold short line
    a. If constrained by an adjacent parallel runway hold short line, stop, and immediately advise ATC
    b. If stopped between parallel runways, only cross when cleared to cross
      - Never cross the solid side of hold short lines without a clearance
  iii. After landing, nonessential communications and actions should not be initiated until clear of all runways

C. RM: Night Operations AI.II.C.R4
  i. Exterior aircraft lights may be used to make an aircraft on the airport surface easier to see
    a. Engines Running: Turn on the rotating beacon whenever an engine is running
    b. Taxiing: Prior to commencing taxi, turn on navigation, position, and anti-collision lights
      - Turn on the taxi light when moving or intending to move on the ground
      - Turn it off when stopped or yielding or as a consideration to other pilots or ground personnel
      - Strobe lights should not be used during taxi if they will adversely affect the vision of others
    c. Crossing a Runway: All exterior lights should be illuminated when crossing a runway
    d. Entering the Departure Runway: Turn on all lights, except for landing lights
      - Line up slightly (3') off centerline to enable a landing aircraft to differentiate you from runway lights
    e. Takeoff: Turn on landing lights when cleared for takeoff, or starting the roll at an uncontrolled airport
  ii. Be more cautious at night
    a. Reduced visibility makes taxiing more difficult
      - Ensure you remain on the assigned route; it is easier to get confused and miss a turn at night
      - Taxi slower, allow yourself ample time to stop if something suddenly appears in front of you
        a Not necessarily another airplane (animal, debris, FOD, etc.)
      - Look closely for taxiway markings (especially hold short lines)
        a Some airports have lights in the ground along with hold short lines, some don't

        b Use lights/lighted signs along taxiway edges to maintain position

D. RM: Low Visibility AI.II.C.R5
   i. AIM 4-3-19 Taxi During Low Visibility
      a. Focus entire attention on the safe operation of the aircraft while it is moving
         - Taxi slowly
         - Focus should be outside
      b. Sterile flight deck - Withold checklists and nonessential communication until stopped with the brakes set
      c. Notify the controller of difficulties or at the first indication of becoming disoriented
      d. Lack of visibility from the tower can prevent visual confirmation of adherence to taxi instructions

E. RM: Loss of SA & Disorientation AI.II.C.R1
   i. Stop if disoriented or SA is lost and inform ATC (or CTAF)
      a. Continuing while disoriented could lead to a runway incursion
      b. Regain orientation before proceeding
   ii. Ask for help
      a. Request progressive, if necessary

7. Case Study: United 1448 (PVD Airport)

A. YouTube Animation & Audio Transcript

B. NTSB Safety Recommendation – July 6, 2000
   i. Page 6 has a short summary and diagram

C. RM Concepts
   i. Highlights low visibility taxi, night operations, loss of SA/disorientation, entering/crossing runways
   ii. Discuss options to mitigate these risks

Conclusion:
Brief review of the main points
One of the biggest safety concerns in aviation is the surface movement accident. By focusing resources to attack this problem head-on, the FAA hopes to reduce and eventually eliminate surface movement accidents.

II.D. Principles of Flight

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives	The learner develops an understanding of the principles of flight. They understand why airplanes are designed in certain ways, as well as the forces acting on airplanes, and how to apply that knowledge to the aircraft in flight.
Key Elements	1. Stability vs. Maneuverability 2. Left Turning Tendency 3. Load Factors
Elements	1. Forces of Flight 2. Airfoil Design 3. Wing Planform 4. Stability, Maneuverability, and Controllability 5. Turning Tendency 6. Load Factors in Airplane Design 7. Wingtip Vortices
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Model Airplane
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the principles to flight and can answer questions regarding lesson concepts.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Everything you ever wanted to know about the science of the airplane, which will result in a considerably better understanding of the airplane and make you a considerably better pilot.

Overview

Review Objectives and Elements/Key ideas

What

Principles of Flight are the characteristic forces of flight as well as why and how the airplane performs certain ways.

Why

To become a pilot, a detailed technical course in the science of aerodynamics is not necessary. However, with the responsibilities for the safety of passengers, the competent pilot must have a well-founded concept of the forces which act on the airplane, and the advantageous use of these forces, as well as the operating limitations of the particular airplane.

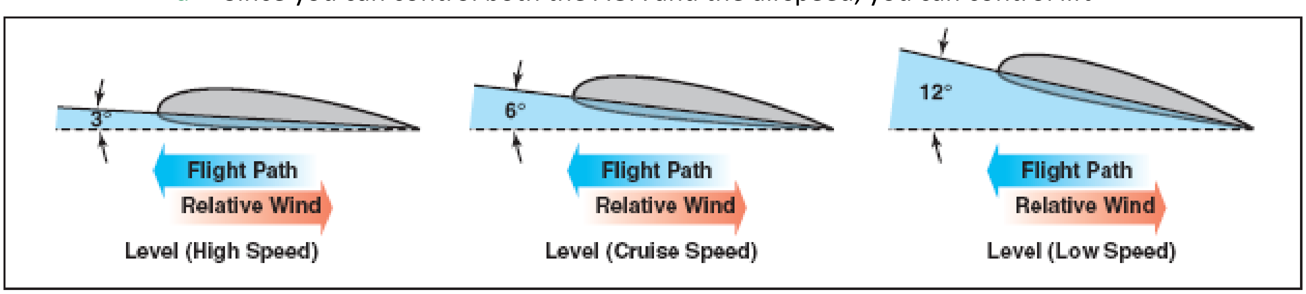
How:

1. **Forces of Flight** AI.II.D.K4
    A. Overview
        i. Lift – The upward force created by the effect of airflow as it passes over and under the wing
        ii. Weight – Opposes lift, and is caused by the downward pull of gravity
        iii. Thrust – The forward force which propels the airplane through the air
        iv. Drag – Opposes thrust, and is the backward, or retarding force, which limits the speed of the airplane
        v. Terminology:
            a. Chord Line: The imaginary straight line joining the leading and trailing edges of an airfoil
            b. Relative Wind: The direction of movement of the wind relative to the aircraft's flight path. It is opposite the aircraft's flight path, and irrespective of the angle of attack
                - EX: Straight and level slow flight and high-speed flight have the same relative wind
            c. Angle of Attack: The angle between the chord line and the relative wind
    B. Lift
        i. The force that opposes weight
        ii. Principles of Lift
            a. Newton's three laws of motion:
                - Newton's 1st Law: A body at rest tends to remain at rest, and a body in motion tends to remain moving at the same speed and in the same direction
                - Newton's 2nd Law: When a body is acted upon by a constant force, its resulting acceleration is inversely proportional to the mass of the body and is directly proportional to the applied force
                    - a The law may be expressed by the following formula: Force = Mass x Acceleration (F=ma)
                - Newton's 3rd Law: For every action, there is an equal and opposite reaction
            b. Bernoulli's Principle
                - As the velocity of a fluid (air) increases, its internal pressure decreases
        iii. Airfoils
            a. An airfoil is any surface, such as a wing, which provides aerodynamic force when it interacts with a

moving stream of air

iv. Airfoils and Lift
   a. Circulation of the airstream about the airfoil is an important factor in the generation of lift
   b. The wing's shape is designed to take advantage of both Newton's Laws and Bernoulli's Principle
      - The greater curvature on the upper portion causes air to accelerate as it passes over the wing
         a According to Bernoulli, the increase in the speed of the air on the top of an airfoil produces a drop in pressure and this lowered pressure results in lift
            1. Molecules moving over the upper surface are forced to move faster
               a. Since the upper molecules travel a greater distance, pressure is reduced above
      - A downward-backward flow of air also is generated from the top surface of the wing
         a The reaction to this downwash results in an upward force on the wing (Newton's 3rd Law)
      - The action/reaction principle is also apparent as the airstream strikes the lower surface of the wing when inclined at a small angle (the angle of attack) to its direction of motion
         a The air is forced downward and therefore causes an upward force resulting in positive lift

v. Pilot Control of Lift
   a. Lift = ½ pC_Lv^2S (Memory Aid: **½ P**int, **C**hug a $_L$iter, **V**omit **twice**, **S**leep it off)
      - P = Rho or a pressure constant
      - C_L = Coefficient of Lift – A way to measure lift as it relates to the angle of attack
         a Determined by wind tunnel tests and based on airfoil design and angle of attack
      - V = Velocity
      - S = Surface Area (Constant)
   b. The amount of lift generated is controlled by the pilot as well as determined by aircraft design factors
      - The pilot can change the Angle of Attack (AOA), the airspeed or you can change the shape of the wing by lowering the flaps
   c. Changing the Angle of Attack
      - AOA - Angle between the chord line of the airfoil and the direction of the relative wind
      - Increasing the AOA increases lift
         a By changing pitch, you change the wing's AOA, and the coefficient of lift (C_L)
   d. Changing Airspeed
      - The faster the wing moves through the air, the more lift is produced
         a Lift is proportional to the square of the airspeed
            1. EX: At 200 knots, an airplane has 4 times the lift as if it was traveling at 100 knots (if other factors remain constant)
               a. But, if the speed is reduced by ½, lift is decreased to ¼ of the previous value
   e. Angle of Attack and Airspeed
      - The AOA establishes the C_L for the airfoil and lift is proportional to the square of the airspeed
         a Since you can control both the AOA and the airspeed, you can control lift



C. Weight
   i. Definition

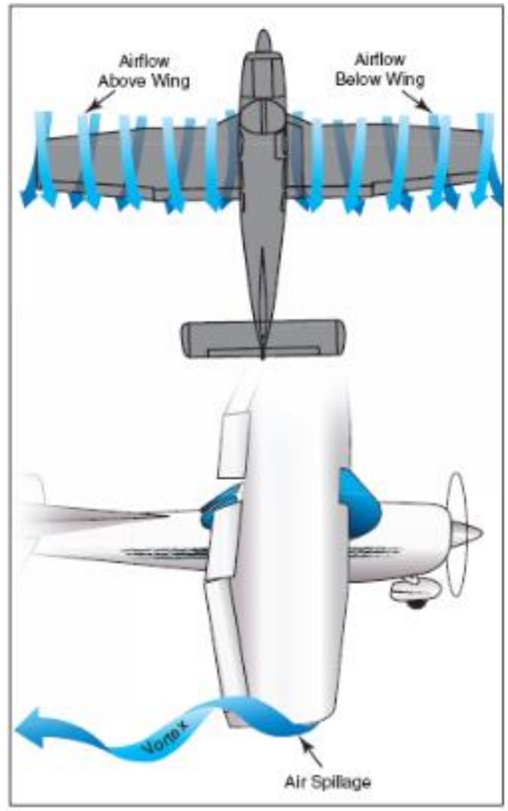
a. The force of gravity which acts vertically through the center of the plane toward the center of earth
b. The combined load of the airplane itself, the crew, the fuel, and the cargo or baggage (everything)

ii. Weight pulls the airplane downward because of the force of gravity
iii. In stabilized level flight, when the lift = weight, the plane is in equilibrium and doesn't gain/lose altitude
   a. If lift becomes less than weight, the airplane loses altitude and the other way around

D. Thrust
   i. Thrust is the forward-acting force which opposes drag and propels the airplane
      a. This force is provided when the engine turns the prop and acts parallel to the longitudinal axis
      b. F=MA
         - Force is provided by the expansion of burning gases in the engine which turns the propeller
         - A mass of air is accelerated opposite to the direction of the flight path (Newton's 3rd Law)
            a The equal/opposite reaction is thrust, a force on the plane in the direction of flight
   ii. Thrust begins the airplane moving, it continues to move and gain speed until thrust and drag are equal
      a. To maintain a constant airspeed, thrust and drag must be equal
      b. If thrust (power) is reduced the plane will decelerate as long as thrust is less than drag
         - If airspeed is increased, thrust becomes greater than drag and airspeed increases until equal

E. Drag
   i. Definition
      a. Rearward, retarding force, caused by disruption of airflow by the wing, fuselage, or other objects
      b. Drag opposes thrust, and acts rearward and parallel to the relative wind
         - Acts in opposition to the direction of flight, opposing the forward-acting force of thrust, and limits the forward speed of the airplane
   ii. Types of Drag
      a. Parasite Drag
         - Caused by an aircraft surface which deflects/interferes with the smooth airflow of the airplane
         - Three Types of Parasite Drag
            a Form Drag: Results from the turbulent wake caused by the separation of airflow from the surface of a structure (The amount is related to the size and shape of the structure)
               1. Basically, how aerodynamic is the aircraft?
            b Interference Drag: Occurs when varied currents of air over an airplane meet and interact
               1. Ex: Mixing of air over structures like wing and tail surface brace struts and gear struts
            c Skin Friction Drag: Caused by the roughness of the airplane's surfaces
               1. A thin layer of air clings to these surfaces and creates small eddies which add to drag
         - Parasite Drag and Airplane Speed
            a The combined effect of all parasite drag varies proportionately to the square of the airspeed
               1. Ex: Plane, at a constant altitude has 4x as the parasite drag at 160 knots than at 80 knots
         - Main Point: As airspeed increases, Parasite drag increases
      b. Induced Drag
         - Systems in General
            a Physical fact that no system, doing work in the mechanical sense, can be 100% efficient
               1. Whatever the nature of the system, the required work is obtained at the expense of certain additional work that is dissipated or lost in the system
               2. The more efficient the system, the smaller the loss
         - The Wing as a System
            a In level flight, the aerodynamic properties of the wing produce lift, but this is obtained at the expense of a penalty, Drag
               1. Induced drag is inherent *whenever* lift is produced

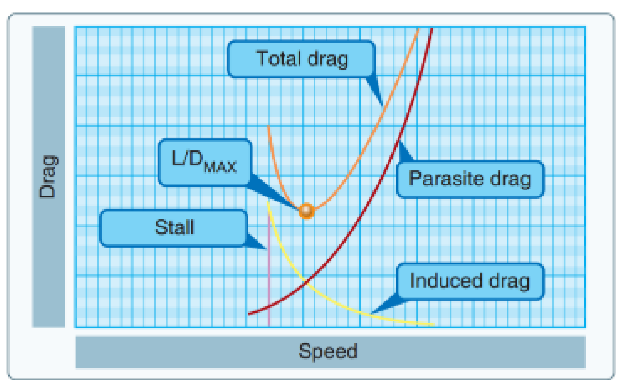
- How it Works
  - a When lift is produced, the pressure on the lower surface is greater than the upper surface
    1. The air flows from the high-pressure area below the wingtip upward to the low pressure
  - b The high-pressure air beneath the wing joins the low-pressure air above the wing at the trailing edge and wingtips causing a spiral or vortex which trails behind each wingtip
    1. The spiral is a lateral flow outward from the underside to the upper surface of the wing
    2. Basically, induced drag is made by the air circulation around the wing as it creates lift
  - c There is an upward flow of air beyond the wingtip and a downwash behind the trailing edge
    1. The downwash has nothing to do with the downwash necessary to produce lift
       - a. It is the source of induced drag
         - i. Vortices increase drag because of the energy spent producing the turbulence
  - d Downwash – The Source
    1. The vortices deflect the airstream downward, creating an increase in downwash
       - a. The wing operates in an average relative wind which is inclined downward and rearward near the wing
    2. Because the lift produced by the wing is perpendicular to the relative wind, the lift is inclined aft by the same amount, reducing it
    3. The greater the size and strength of the vortices, and therefore the downwash component, the greater the induced drag becomes
  - e The lower the airspeed, the greater the angle of attack required to produce lift equal to the airplane's weight, and the greater the induced drag
    1. Induced drag varies inversely as the square of the airspeed



- Main Point: As lift increases, induced drag increases

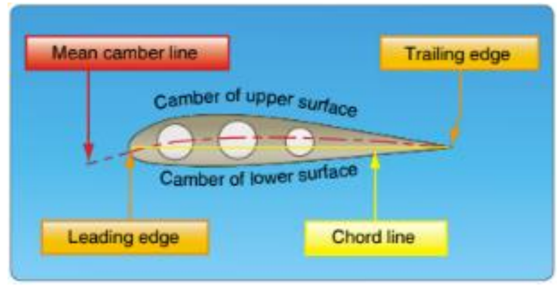
c. Total Drag

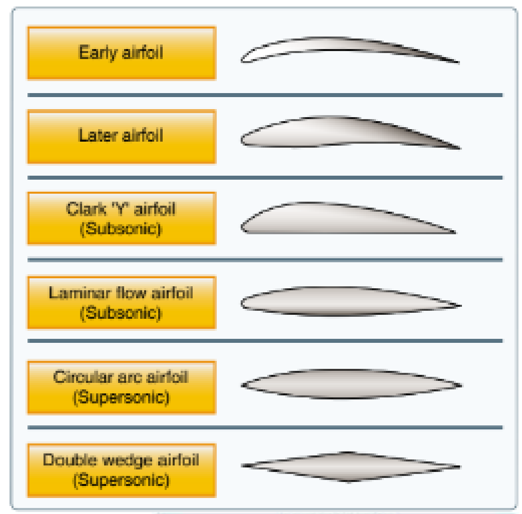
- The sum of induced and parasitic drag
- Region of Normal vs Reversed Command
  - a Normal Command
    1. As airspeed decreases, total drag decreases, to a point (L/D_{MAX})
    2. Maintaining an altitude, higher speeds require higher power settings & lower speeds require lower power settings
  - b Region of Reversed Command
    1. As airspeed decreases below L/D_{MAX}, total drag begins to increase
       - a. This is referred to as the region of reversed command
    2. Below L/D_{MAX}, while maintaining altitude, slower speeds require higher power settings and faster speeds require lower power settings



2. Airfoil Design

AI.II.D.K1

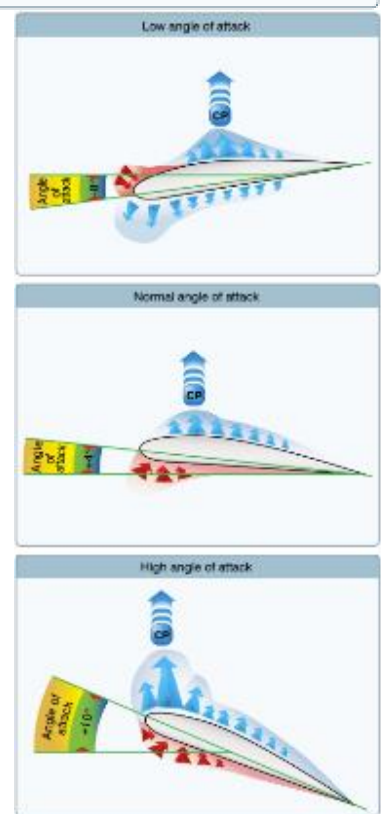




A. Airfoil: Structure designed to obtain reaction upon its surface from the air through which it moves or that moves past such a structure

B. Terminology
- i. Camber
  - a. Curvature of the upper / lower surface
  - b. Upper surface tends to have more camber
- ii. Leading edge / Trailing edge
  - a. Generally rounded leading edge
  - b. Generally narrow and tapered trailing edge
- iii. Chord Line
  - a. Straight line drawn through the airfoil profile connecting the extremities of the leading and trailing edges
  - b. Distance from the chord line to the upper / lower surfaces denotes the magnitude of camber
- iv. Mean Camber Line
  - a. Equidistant at all points from the upper and lower surfaces

C. General Design Characteristics
- i. Air Pressure
  - a. Airfoil is constructed to take advantage of the air's response to physical laws
  - b. This develops two actions from the air mass:
    - Negative pressure lifting action above the wing
    - Positive pressure lifting action from below the wing
  - c. Different airfoils have different flight characteristics (pictured above)
    - Aircraft weight, speed & purpose dictate the airfoil shape
- ii. Low Pressure Above
  - a. Air moving over the upper surface of the airfoil moves faster than air along the bottom
    - Upper surface has a higher camber in this case
    - Bernoulli's Principle: Increase in speed of air across the top of an airfoil decreases pressure
  - b. Downward, backward flow of air creates downwash
    - Newton's 3rd Law: Downward, backward flow results in an upward force on the airfoil
- iii. High Pressure Below
  - a. Positive pressure from below the airfoil
    - Particularly at higher AOAs
    - Newton's 3rd Law
  - b. Stagnation Point: Near the leading edge there is a point where the airflow is virtually stopped
    - Speed gradually increases, matching the velocity of the air on the upper surface near the trailing edge
    - Slower airflow = increased pressure (Bernoulli's principle)
- iv. Pressure Distribution (pictured, right)
  - a. At different AOAs, pressures vary between positive / negative



b. Negative pressure on the upper surface creates a larger force than the positive pressure from air striking the lower surface
c. Center of Pressure (CP): Average of the pressure variation for a given AOA
- Aerodynamic forces act through the CP
- At high AOAs, the CP moves forward
- At low AOAs, the CP moves aft

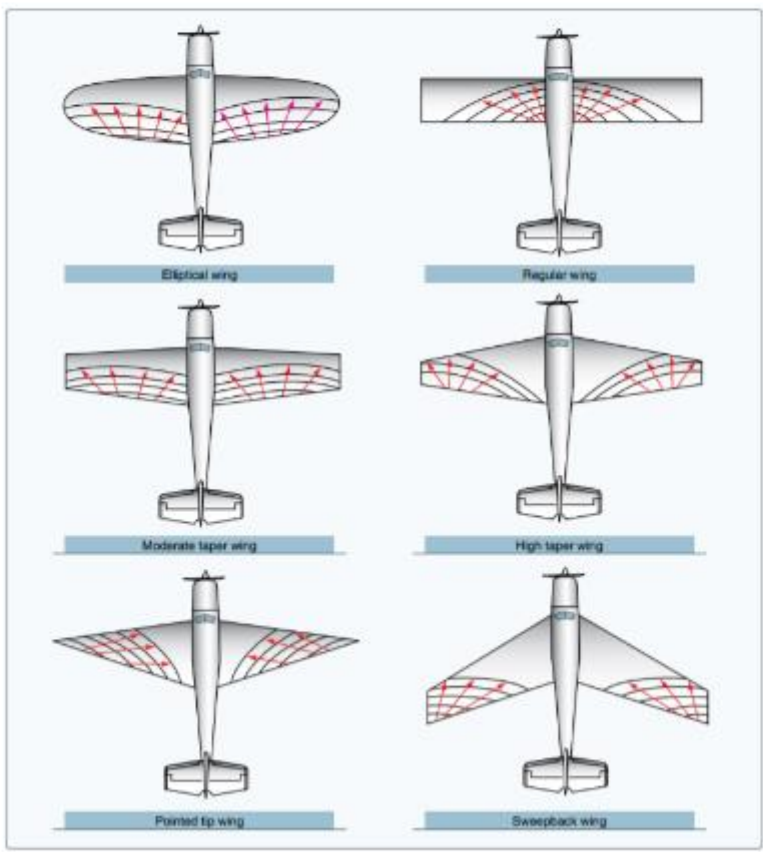
d. CP movement is very important to wing structure design
- Affects aerodynamic balance and controllability

v. Note: The production of lift is much more complex than a simple differential pressure between the upper and lower airfoil surfaces, but these concepts suffice for this discussion

3. Wing Planform & Terminology

A. Planform describes the wings outline as seen from above
i. Many factors affect shape, including purpose, load factors, speeds, construction and maintenance costs, maneuverability/stability, stall/spin characteristics, fuel tanks, high lift devices, gear, etc.
ii. There are many different shapes and advantages/disadvantages to each (many shapes are combined)

B. Taper – Ratio of the root chord to tip chord
i. Rectangular wings have a taper ratio of 1
a. Simpler and more economical to produce/repair (ribs are same size)
b. Root stalls first providing more warning and control during recovery
ii. Ellipse (Tapered)
a. Provides best span wise load distribution and lowest induced drag
b. But the whole wing stalls at the same time; very expensive/complex to build



C. Aspect Ratio – divide the wingspan by the average chord
i. The greater the aspect ratio, the less induced drag (more lift)
ii. Increasing wingspan (with the same area) results in smaller wingtips, generating smaller vortices
a. Reduces induced drag and are more efficient
b. Planes requiring extreme maneuverability and strength have much lower aspect ratios
- Ex: Fighter, and aerobatic aircraft

D. Sweep – When the line connecting the 25% chord points of the ribs isn't perpendicular to the longitudinal axis
i. The sweep can be forward, but it is usually backward
ii. Helps in flying near the speed of sound, but also contributes to lateral stability in low-speed planes

4. Stability, Maneuverability, and Controllability AI.II.D.K2

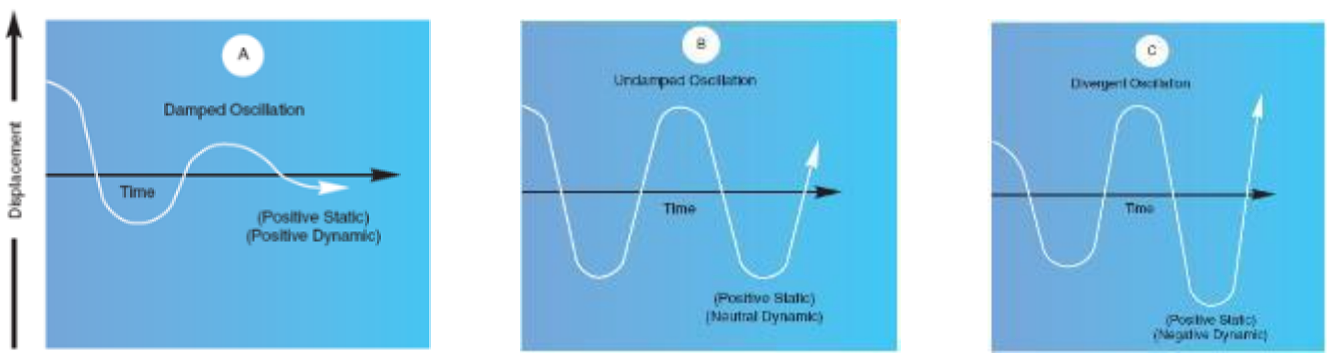
A. Stability
i. The inherent quality of an airplane to correct for conditions that may disturb its equilibrium, and return to or continue the original flight path
a. Stability is primarily a design characteristic

  b. The more stability, the easier to fly, but too much results in significant effort to maneuver
    - Therefore, stability and maneuverability must be balanced

ii. There are two types of stability: Static and Dynamic

iii. Static Stability (SS)
  a. Equilibrium: All opposing forces are balanced (Steady unaccelerated flight conditions)
  b. SS: The *initial tendency*; The aircraft's initial response when disturbed from a given pitch, yaw, or bank
    - Positive SS: The initial tendency to return to the original state of equilibrium after being disturbed (to return to the trimmed condition)
    - Negative SS: The initial tendency to continue away from original equilibrium after being disturbed (the aircraft moves farther and farther away from the trimmed position)
    - Neutral SS: The initial tendency to remain in a new condition after equilibrium has been disturbed (the aircraft remains in a new position and does not return or trend away from the original trimmed position)
  c. Positive SS is the most desirable - The plane attempts to return to the original trimmed attitude

iv. Dynamic Stability (DS)
  a. SS refers to the initial tendency, DS refers to the aircraft response over time when disturbed from a given pitch, bank, or yaw
    - Refers to whether the disturbed system returns to equilibrium over time or not
    - The degree of stability can be gauged in terms of how quickly it returns to equilibrium
    - Referred to as Positive, Negative, and Neutral – Same as SS, but over time (overall tendency)
  b. Most desirable is Positive Dynamic Stability



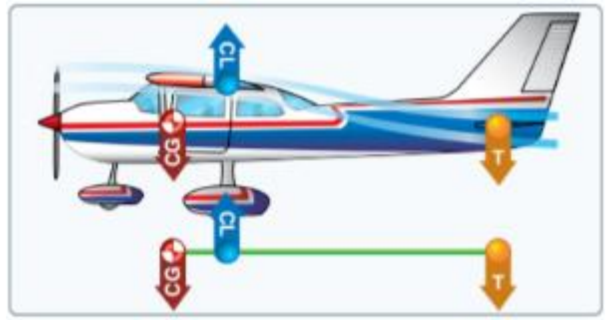
v. Stability in an aircraft significantly affects two areas:
  a. Controllability – Capability of the aircraft to respond to the pilot's control, especially in regard to flight path and attitude
    - Quality of the aircraft's response to control application when maneuvering the aircraft, regardless of stability characteristics
  b. Maneuverability - Quality of the aircraft that permits it to be maneuvered easily and to withstand stresses imposed by maneuvers
    - Governed by weight, inertia, size and location of flight controls, structural strength and power plant
    - It is a design characteristic

B. Longitudinal Stability (LS) – About the lateral axis

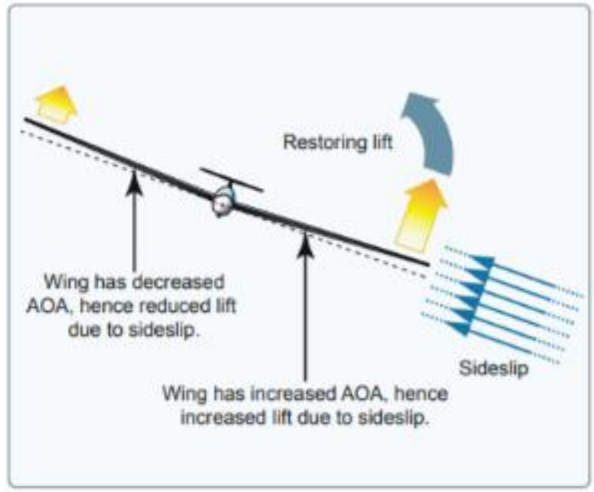
i. LS makes an airplane stable about its lateral axis and involves the pitching motion
  a. A Longitudinally unstable plane tends to dive and climb progressively steeper making it difficult/dangerous to fly

ii. To obtain LS, the relation of the wing and tail moments must be such that, if the moments are balanced and the airplane is suddenly nosed up, the wing moments and tail moments will change so that their forces will provide a restoring moment bringing the nose down again

        a. And, if the plane is nosed down, the change in moments will bring the nose back up
    iii. Static LS, or instability, is dependent on 3 factors:
        a. Location of the wing in relation to the Center of Gravity (CG)
            - The CG is usually ahead of the wing's Center of Lift (CL) resulting in nose down pitch
            - This nose heaviness is balanced by a downward force generated by the horizontal tail
                a The horizontal stabilizer is often designed with a negative AOA to create a natural tail-down force
                b Remember, the tail down force lifts the nose of the aircraft up (pitch up motion)
            - The CG-CL-Tail-down force line is like a lever with an upward force at CL and 2 downward forces (CG and Tail-down) on either side balancing each other
                a The stronger down force is at the CG; tail down force is weaker but has a longer arm



            - In the case of a dynamically stable aircraft: If the nose is pitched up (with no other change in controls/power), airspeed will begin to decrease. As airspeed decreases, the tail-down force of the elevator will decrease. As the tail-down force decreases, the nose of the aircraft will begin to pitch down, resulting in increased airspeed. As airspeed increases, the tail-down force of the stabilizer will increase, lifting the nose back up. If left untouched, this process will continue, and each pitch up/down will progressively weaken until the aircraft returns to stabilized flight.
        b. Location of the horizontal tail surfaces with respect the CG
            - If the plane is loaded with the CG farther forward, more tail down force is necessary
                a This adds to longitudinal stability since the nose heaviness makes it more difficult to raise the nose and the additional tail down forces makes it difficult to pitch down
                    1. Any small disturbances are opposed by larger forces, dampening them quickly
            - If the plane is loaded farther aft, the plane becomes less stable in pitch
                a If the CG is behind the CL, the tail must exert upward force so the nose doesn't pitch up
                b If a gust pitches the nose up, less airflow over the tail will cause the nose to pitch further
                c This is an extremely dangerous situation
        c. The area or size of the tail surfaces
            - The larger the area/size of the tail surface, the more force exerted
C. Lateral Stability - About the Longitudinal Axis
    i. Lateral stability about the longitudinal axis is affected by:
        a. Dihedral; Sweepback Angles; Keel Effect; Weight Distribution
    ii. Dihedral is the angle at which the wings are slanted upward from the root to the tip
        a. Some aircraft are designed so that the outer tips of the wings are higher than the wing roots
            - Dihedral is the upward angle formed by the wings
        b. Dihedral stabilizes the airplane by balancing the lift in a sideslip
            - When a gust causes a roll, a sideslip will result



- The sideslip causes the relative wind affecting the airplane to be from the direction of slip
- When the relative wind comes from the side, the wing slipping into the wind (low wing) gets an increase in AOA and develops an increase in lift
- The wing away from the slip (high wing), is subject to a decrease in AOA and lift
- The changes in lift result in a rolling moment that raises the lowered wing (more stable)

c. In a shallow turn: the increased AOA increases lift on the low wing with a tendency to return the aircraft to straight and level flight

iii. Sweepback is the angle at which the wings are slanted rearward from the root tip
   a. Sweepback effectively increases dihedral to achieve stability, but the effect is not as pronounced
      - A rough estimation is that 10º of sweepback is equal to about 1º of effective dihedral
   b. When a disturbance causes an aircraft with a sweepback to drop a wing, the low wing presents its leading edge at an angle that is more perpendicular to the airflow. This results in more lift on the lowered wing

iv. Keel effect depends on the action of the relative wind on the side area of the fuselage
   a. Laterally stable airplanes: The greater portion of the keel area is above and behind the CG
      - When the plane slips to one side, the combination of the airplane's weight and the pressure of the airflow against the upper portion of the keel area rolls the plane back to wings level
         - a The fuselage behaves like a keel, exerting a steadying influence on the aircraft
   b. To Summarize: The fuselage is forced by keel effect to parallel the wind

v. Weight Distribution
   a. If more weight is located on one side, it will tend to bank that direction

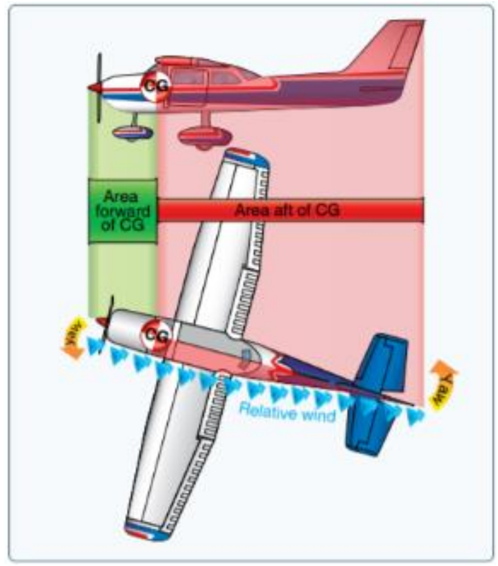
D. Directional Stability (DS) - Stability about the vertical axis

i. DS is affected by the area of the vertical fin and the sides of the fuselage aft of the CG
   a. Makes the airplane act like a weathervane, pointing the nose into the relative wind

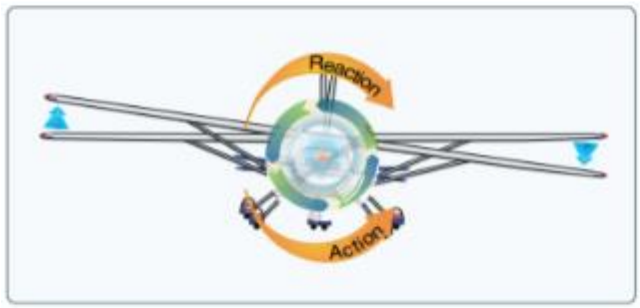
ii. SIDE - For a weathervane to work, a greater surface area must be aft of the pivot point (the CG)
   a. If the same amount of surface area were exposed to the wind in front of and behind the pivot point, the forces would balance and there would be little or no directional movement
   b. Ex: If the nose yaws left, it will pivot around the CG. As the aircraft yaws, the relative wind will push on the right side of the fuselage. Since there is more surface area behind the pivot point (CG), there is more force applied behind the CG and the nose will be pushed back to the right

iii. VERTICAL FIN – the vertical fin acts like a feather on an arrow in maintaining straight flight (pictured below)
   a. The farther aft the fin is placed and the larger its size, the greater the DS
   b. As the plane yaws in one direction, the air strikes the opposite side of the vertical fin
      - This puts pressure on vertical fin, stopping the motion and then turning the nose into the relative wind (like a weathervane)

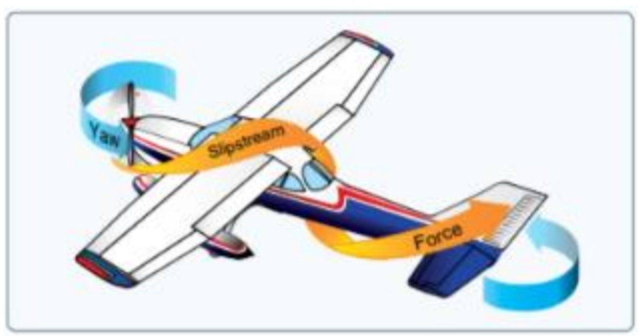
- Ex: If the nose yaws right, the relative wind puts pressure on the left side of the vertical stabilizer stopping the yaw and moving the nose back to the left



5. **Turning Tendency** AI.II.D.K3
   A. Torque is made up of 4 elements which produce a twisting or rotating motion around at least 1 of the 3 axes
      i. Torque Reaction from the engine and propeller, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Propeller, and P-Factor, or asymmetric loading of the propeller
   B. Torque Reaction
      i. Newton's 3rd Law – For every action there is an equal and opposite reaction
         a. The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction
      ii. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency
      iii. On the ground, during takeoff, the left side is being forced down resulting in more ground friction
         a. This causes a turning moment to the left that is corrected with rudder
      iv. The strength of the torque reaction is dependent on engine size and horsepower, propeller size and rpm, airplane size, and the condition of the ground surface
         - The higher the power setting, the greater the left turning tendency

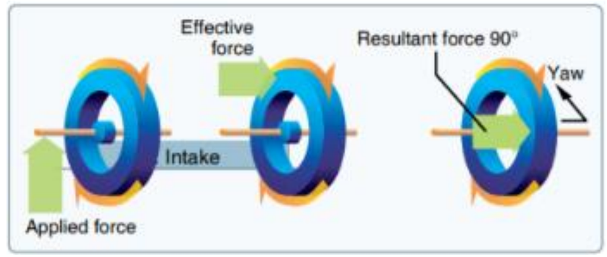


      v. Torque is corrected by offsetting the engine, aileron trim tabs, and/or aileron/rudder use
         a. Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset to counteract a portion of the rolling motion caused by torque
         b. Trim tabs can be adjusted to counter the turning tendency in level flight
         c. Some airplanes are designed to create more lift on the wing that is forced downward as well
         d. Torque not countered by the engine and trim tab position must be corrected with coordinated rudder and aileron inputs
   C. Corkscrew/Slipstream Effect
      i. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft where the air strikes the left side of the vertical stabilizer, pushing the nose to the left



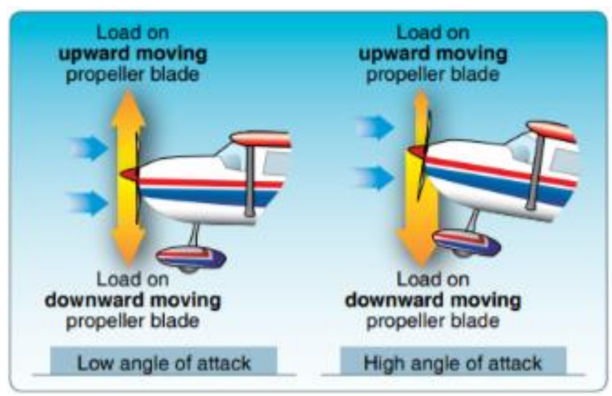
      ii. At high prop speeds/low forward speeds the rotation is very compact
         a. This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
         b. The corkscrew flow also creates a rolling moment around the longitudinal axis
            - The rolling moment is to the right and may counteract torque to an extent
      iii. As the forward speed increases, the spiral elongates and becomes less effective
      iv. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in takeoffs and climbs (high prop speed and low forward speed)

D. Gyroscopic Action
   i. Gyroscopes are based on two fundamental principles:
      a. Rigidity in space (not applicable to this discussion)
      b. Precession - The resultant action of a spinning rotor when a force is applied to its rim
         - If a force is applied, it takes effect 90º ahead of, and in the direction of turn
            a This causes a pitch moment, yaw moment, or combination of the two depending on where the force is applied
         - Ex: Most often occurs with tail wheel aircraft when the tail is raised on the takeoff roll
            a The change in pitch (lifting the tail wheel) has the same effect as applying a forward force to the top of the propeller
               1. This force is felt 90º in the direction of rotation (clockwise viewed from the flight deck)
            b The forward force will take effect on the right side of the propeller, yawing the nose left



   ii. Any yawing around the vertical axis results in a pitching moment
   iii. Any pitching around the lateral axis results in a yawing moment
   iv. Correction is made with proper elevator and rudder pressures to prevent undesired pitch and yaw

E. Asymmetric Loading (P Factor)
   i. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade
      a. This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)
   ii. P-factor is caused by the propeller's resultant velocity, which is generated by the combination of two parts:
      a. The velocity of the propeller blade in its plane of rotation
      b. The velocity of the air passing horizontally through the propeller disc
   iii. At positive AOAs, the right (down swinging) blade is passing through an area of resultant velocity greater than the left (up swinging) blade
      a. Since the prop is an airfoil, increased velocity means increased lift
         - Therefore, the down blade has more lift and tends to yaw the plane to the left



   iv. Ex: Visualize the propeller shaft mounted perpendicular to the ground (like a helicopter)
      a. If there were no air movement at all, except that generated by the propeller, identical sections of the blade would have the same airspeed
      b. But, with air moving horizontally across the vertically mounted prop, the blade proceeding forward into the flow of air will have a higher airspeed than the blade retreating with the airflow
         - The blade proceeding into the airflow creates more lift, moving the center of lift toward it
      c. Visualize rotating the vertically mounted propeller to shallower angles relative to the moving air (as on an airplane)
         - Unbalanced thrust gets proportionately smaller until it reaches zero when the propeller shaft is exactly horizontal in relation to the moving air
   v. Summary: Descending propeller blade has a higher AOA resulting in a bigger bite of air; therefore, the center of thrust is moved to the right side of the aircraft's centerline and there will be a tendency to yaw left

6. Load Factors (LF) in Airplane Design AI.II.D.K5

A. General
   i. Load factor is the ratio of the total air load acting on the airplane to the gross weight of the airplane

ii. Measured in Gs (acceleration of gravity)
   a. Gs can be positive or negative
      - Ex of positive Gs: A sharp pull up and the resulting force pushing the pilot into the seat
      - Ex of negative Gs: A sharp push down and the resulting force lifting the pilot off the seat
   b. 1 G is equivalent to normal gravitational forces (at 1 G, a 200 lb. person weighs 200 lbs.)
   c. 2 Gs is double – (at 200 Gs, a 200 lb. person weighs 400 lbs.), 3 is triple, etc.
   d. 0.5 Gs is equivalent to half of the weight of the aircraft or person

iii. Ex: A load factor of 3 means that the total load supported by the airplane is three times its weight
   - Expressed as 3 Gs
   - If an aircraft is pulled up from a dive, subjecting the pilot to 3 Gs, the pilot would be pressed down into the seat with a force equal to three times their weight
      a The wings of the airplane would also be supporting 3x the weight of the airplane

iv. Load factor is important to the pilot for two distinct reasons:
   a. It is possible for the pilot to impose a dangerous overload on the aircraft structures
      - Aircraft are designed to withstand a certain range of load factors
      - For example, normal category aircraft are designed to operate between -1.52 and 3.8 Gs
         a Exceeding these ranges can damage the structure and lead to failure
   b. An increased LF increases the stall speed and makes stalls possible at seemingly safe speeds

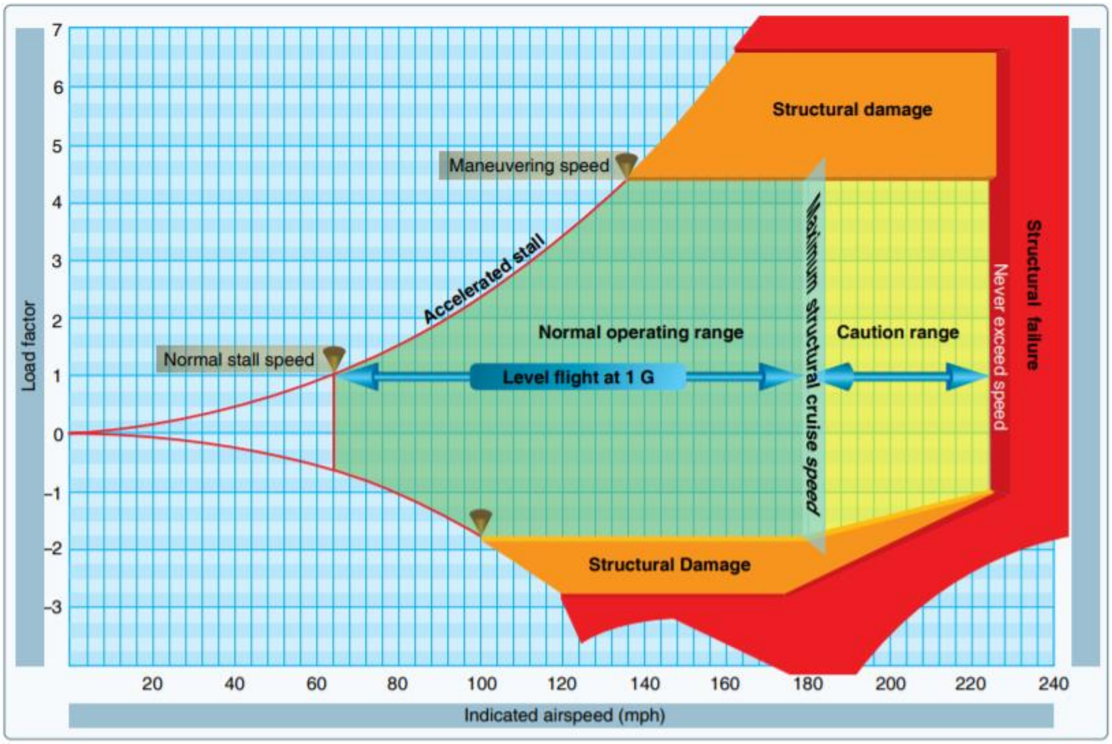
B. Airplane Design
   i. How strong an airplane should be is determined largely by the use it will be subjected to
      a. This is difficult as maximum possible loads are much too high to incorporate in efficient design
         - If planes are to be built efficiently, extremely excessive loads must be dismissed
         - The idea is to determine the highest LF that can be expected in normal operation under various operational situations – These are 'limit load factors'
            a Planes must be designed to withstand limit load factors with no structural damage
   ii. Airplanes are designed in accordance with the category system:
      a. Normal Category limit load factors are -1.52 Gs to 3.8 Gs
      b. Utility Category limit load factors are -1.76 Gs to 4.4 Gs (Mild acrobatics, including spins)
      c. Acrobatic Category limit load factors are -3.0 Gs to 6.0 Gs

C. The Vg diagram shows the flight operating strength of a plane based on load factor (vertical scale) and indicated airspeed (horizontal scale) – describes the allowable airspeed/LF combinations for safe flight
   i. Each aircraft has its own Vg diagram that is valid at a certain weight and altitude
   ii. Areas to note on the Vg diagram:
      a. Lines of Maximum Lift Capability (curved lines)
         - The aircraft in this diagram can develop no more than 1 G at 64 mph, the wings level stall speed of the airplane
         - Since the maximum load factor varies with the square of the airspeed, the maximum positive lift capability of this aircraft is 2 G at 92 mph, 3 G at 112, 4.4 G at 137, etc.
         - Any load factor above this line is unavailable aerodynamically
            a i.e., the aircraft cannot fly above the line of maximum lift capability because it stalls
            b The same situation occurs for negative lift flight
         - If the aircraft is flown at a positive load factor greater than the limit of 4.4 Gs, structural damage is possible
      b. Maneuvering Speed
         - The intersection of the positive limit load factor (4.4 Gs) and the line of maximum positive lift capability
         - This is the minimum airspeed at which the limit load can be developed aerodynamically

- Any speed greater than this provides the capability to damage the aircraft
- Speeds less than this do not provide the lift capability to cause damage from excessive loads

c. Intersection of the Negative Limit Load Factor and Line of Maximum Negative Lift Capability
- Airspeeds greater than this provide a negative lift capability that can damage the aircraft
- Airspeeds less do not provide the lift capability to cause damage from excessive loads

d. Limit Airspeed (redline)
- This aircraft is limited to 225 mph
- Above this speed, structural damage or failure may result



7. Wingtip Vortices

AI.II.D.K6

A. How They Work

i. When an airfoil is flown at a positive AOA, a pressure differential exists above and below the wing

ii. The pressure above the wing is less than atmospheric pressure

iii. The pressure below the wing is equal to or greater than atmospheric pressure

iv. Since air always move from higher to lower pressure, and the path of least resistance is the tips of the wings, there is a spanwise movement of air from the bottom of the wing outward from the fuselage to the tips

v. This flow of air spills over the wingtips

vi. As the air curls upward around the wingtip, it combines with downwash to form a fast-spinning trailing vortex

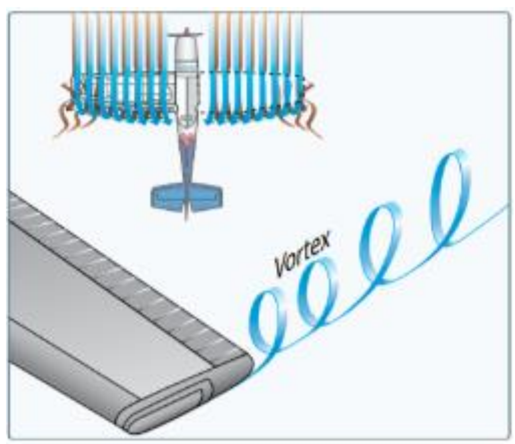
a. These vortices increase drag because of energy spent in producing the turbulence

vii. Thus, whenever an airfoil is producing lift, induced drag occurs and wingtip vortices are created

a. Just as lift increases with AOA, induced drag also increases

b. As AOA increases, there is a greater pressure difference between the top/bottom of the wing

- Greater pressure difference = greater lateral airflow



and stronger vortices

B. Strength of the Vortices
   i. As mentioned, the greater the AOA, the stronger the vortices
      a. Therefore, the strongest vortices occur when the aircraft is heavy, clean, and slow
      b. Strength is directly proportional to weight and inversely proportional to wingspan and airspeed
         - As weight increases, AOA increases
         - A wing in the clean configuration has a greater AOA than with flaps, slats, etc. in use
         - As airspeed decreases, AOA increases
   ii. Thus, the strongest vortices occur during takeoff, climb, and landing

C. Dangers of Vortices
   i. Wake turbulence can be a hazard to any aircraft significantly lighter than the generating aircraft
   ii. Flying through another aircraft's wake can result in major structural damage, or induced rolling making the aircraft uncontrollable

D. Behavior and Avoidance
   i. Behavior
      a. Sink at a rate of several hundred fpm, slowing/diminishing the further they get behind an aircraft
      b. When vortices sink to the ground, they tend to move laterally with the wind
         - A crosswind will decrease lateral movement of the upwind vortex and increase movement of downwind vortex
            a Be cautious, this could move another aircraft's vortices into your path
         - A tailwind can move the vortices of a preceding aircraft forward into the touchdown zone
   ii. Avoidance
      a. To minimize the chances of flying through another aircraft's wake:
         - Takeoff:
            a Takeoff prior to the point the preceding aircraft rotated, and attempt to climb above or away from their flight path
            b Takeoff after a landing jet's touchdown point
         - Enroute:
            a Avoid flying through another aircraft's flight path
            b Avoid following another aircraft on a similar flight path at an altitude within 1,000'
         - Landing:
            a Stay above a preceding aircraft's path, and land past their touch down point
            b Parallel runways – stay at and above the other jet's flight path for the possibility of drift
            c Crossing runways – cross above the larger jet's flight path
            d Land prior to a departing aircraft's takeoff point

E. For more information, see lesson VI.B. Traffic Patterns, Wake Turbulence

RM: Basic aerodynamic principles of flight AI.II.D.R1

The lesson as a whole is a discussion of managing risk associated with aerdynamic principles

Conclusion:

Brief review of the main points

The competent pilot must have a well-founded concept of the forces which act on the airplane, and the advantageous use of these forces, as well as the operating limitations of the airplane.

II.D. Principles of Flight (Additional Information)

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives	The learner understands how the forces of flight affect the aircraft in different phases of flight.
Key Elements	1. Pilot Control of Lift 2. Parasite vs. Induced Drag 3. Ground Effect
Elements	1. Ground Effect 2. Climbs 3. Descents 4. Turns 5. Stalls
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Model Airplane
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner displays the ability to explain the forces of flight and their interaction and effect on flight.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Everything you ever wanted to know about the science of the airplane which will result in a considerably better understanding of the airplane and hopefully make you a considerably better pilot.

Overview

Review Objectives and Elements/Key ideas

What:

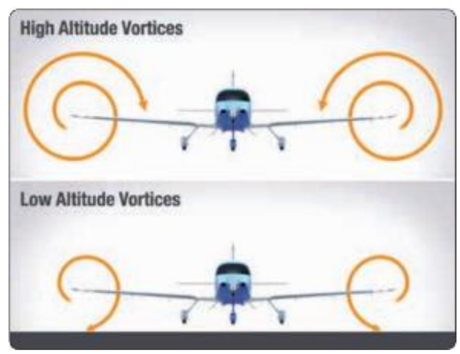
How the forces of flight affect the airplane in different phases of flight.

Why:

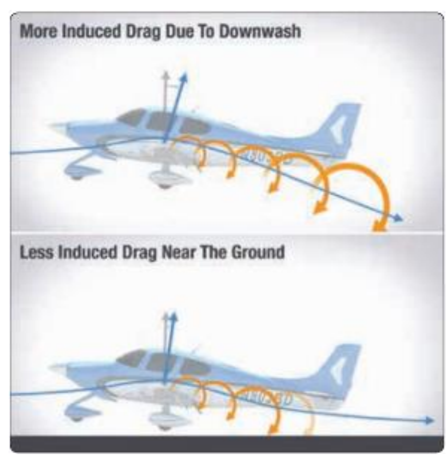
How well a pilot performs in flight depends on the ability to plan and coordinate the use of power and flight controls to change the forces of thrust, drag, lift, and weight. It is the balance between these forces that the pilot must always control. The better the understanding of the forces, and means of controlling them, the greater the pilot's skill.

How:

1. **Ground Effect**
   A. Associated with the reduction of induced drag
   B. Explanation
      i. When flying close to the ground, the vertical component of the airflow around the wing is restricted by the ground
         a. Causes a reduction in wingtip vortices and a decrease in upwash and downwash
         b. Since ground effect restricts downward deflection of the air, induced drag decreases



   C. Effects on Flight
      i. Takeoff
         a. With the reduction of induced drag, the amount of thrust required to produce lift is reduced
            - Therefore, the plane is capable of lifting off at lower-than-normal takeoff speed
         b. As you climb out of ground effect, the power (thrust) required to sustain flight increases significantly as the normal airflow around the wing returns and induced drag is increased
            - If you climb out before reaching normal takeoff speed the plane can sink back to the surface
      ii. Landing
         a. Decrease in induced drag makes the plane seem to float
            - Power reduction is usually required during the flare



2. **Climbs**
   A. In a steady state, normal climb the wing's lift is the same as it is in level flight at the same airspeed
      i. Though the flight path changes when the climb is established, AOA and lift basically stay the same
   B. During the change from straight and level to a climb, a change in lift occurs when elevator is 1st applied

    i. Raising the airplane's nose increases the AOA and momentarily increases lift
    ii. Lift at this moment is now greater than weight and starts the airplane climbing
  C. Once the flight path is stabilized, the AOA and lift revert to approximately level flight values
  D. If the climb is entered with no change in power settings, the airspeed gradually diminishes
    i. This is because thrust required to maintain an airspeed in level flight cannot maintain the airspeed in a climb
    ii. When inclined upward, a component of weight acts in the same direction as, and parallel to drag
      a. This increases drag (drag is greater than thrust and therefore airspeed will decrease until equal)
  E. Since, in a climb, weight is not only acting downward but rearward along with drag, additional power is needed to maintain the same airspeed as in level flight
    i. The amount of reserve power determines the climb performance

3. Descents

  A. When forward pressure is applied, the AOA is decreased and, as a result, the lift of the airfoil is reduced
    i. Reduction in lift/AOA is momentary and occurs during the time the flight path changes downward
    ii. The change to a downward flight path is due to the lift momentarily becoming less than weight
  B. When the flight path is in a steady descent, the airfoil's AOA again approaches the original value and lift and weight become stabilized
  C. From the time the descent is started until it is stabilized, the airspeed will gradually increase
    i. This is due to a component of weight acting forward along the flight path (like rearward in a climb)
      a. Thrust is greater than drag
  D. To descend at the same airspeed, power must be reduced when the descent is entered
    i. The amount of power is dependent on the steepness of the descent
      a. The component of weight acting forward will increase with an increase in angle of descent

4. Turns

  A. Like any moving object, an airplane requires a sideward force to make it turn
    i. In a normal turn, this force is supplied by banking so that lift is exerted inward as well as upward
  B. When the airplane banks, lift acts inward toward the center of the turn, as well as upward
    i. Lift is divided into two components, the horizontal component and the vertical component
      a. Vertical Component – Acts vertically and opposite to weight
      b. Horizontal Component – Acts horizontally toward the center of the turn (Centripetal Force)
        - This is what makes the airplane turn
    ii. The division of lift reduces the amount of lift opposing gravity and supporting weight
      a. Consequently, the airplane will lose altitude unless additional lift is created
        - This is done by increasing the AOA until the vertical component of lift again equals weight
      b. Since the vertical component of lift decreases as bank increases, AOA must be increased as the bank angle is steepened
  C. Holding Altitude
    i. To provide a vertical component of lift sufficient to hold altitude, an increase in the AOA is required
    ii. Since drag is directly proportional to AOA, induced drag will increase as lift is increased
      a. This in turn, causes a loss of airspeed in proportion to the angle of bank
    iii. Additional power must be applied to prevent airspeed from reducing in level turns
      a. The required amount of additional thrust is proportional to the angle of bank
  D. Rate of Turn
    i. The rate at which an airplane turns depends on the magnitude of the horizontal component of lift
      a. The horizontal component of lift is proportional to the angle of bank
    ii. Therefore, at any given airspeed, the rate of turn can be controlled by adjusting the angle of bank
  E. Turning Radius
    i. Increased airspeed results in an increased turn radius and centrifugal force is directly related to radius
      a. The increase of the radius of the turn causes an increase in centrifugal force which must be balanced by

an increase in the horizontal component of lift
- The horizontal component of lift can only be increased by increasing bank angle

ii. To maintain a constant rate of turn with an increased airspeed, the angle of bank must be increased

F. Slipping Turns
i. In a slipping turn, the rate of turn is too slow for the angle of bank, and the plane is yawed to the outside of the turning flight path
a. The horizontal component (H_{CL}) of lift is greater than Centrifugal Force (CF)
ii. H_{CL} and CF equilibrium is reestablished by decreasing bank/increasing the rate of turn
a. Increase or decrease rudder pressure to center the ball or adjust bank

G. Skidding Turns
i. In a skidding turn, the rate of turn is too great for the angle of bank and the plane is yawed inside the turn
a. There is excess centrifugal force compared to the H_{CL}
ii. Correction involves reducing the rate of turn/increasing the bank
a. Increase of decrease rudder pressure as necessary or adjust bank

5. Stalls

A. As long as the wing is creating sufficient lift to counteract the load imposed on it, the plane will fly
i. When the lift is completely lost, the airplane will stall

B. The direct cause of every stall is an excessive angle of attack

C. The stalling speed of a particular airplane is not a fixed value for all flight situations
i. However, a given airplane will always stall at the same AOA regardless of speed, weight, load factor, or density altitude
ii. Each plane has a particular AOA where airflow separates from the upper wing and it stalls (16º-20º)

D. 3 situations where the critical AOA can be exceeded:
i. Low Speed Flying
a. As airspeed is decreased, the AOA must be increased to retain the lift required to hold altitude
b. The slower the airspeed, the more AOA must increase. At the critical AOA, lift cannot increase further
- If airspeed is reduced, the airplane will stall, since the AOA has exceeded the critical AOA

ii. High Speed Flying
a. Low speed is not necessary to produce a stall
b. The wing can be brought to an excessive angle of attack at any speed
c. Ex: diving at 200 knots with a sudden increase in back elevator pressure
- Because of gravity and centrifugal force, the plane cannot immediately alter its flight path
  a It would merely change its AOA abruptly from very low to very high
- Since the flight path of the airplane in relation to the oncoming air determines the direction of the relative wind, the AOA is increased, and the stalling angle would be reached

iii. Turning Flight
a. The stalling speed of an aircraft is higher in a level turn than in straight and level flight
- This is because the centrifugal force is added to the plane’s weight
  a The wing must produce sufficient additional lift to counteract the load imposed

b. In a turn, the necessary additional lift is acquired by applying back pressure
- This increases the wings AOA (AOA increases with the bank angle to maintain level flight)

c. If at any time during a turn the AOA becomes excessive, the airplane will stall

Conclusion:
Brief review of each main point

II.E. Flight Controls & Operation of Systems

Select the aircraft systems lesson from the Navigation menu, or use the links below:

GENERIC
Generic Aircraft (PHOAK material)

CESSNA
Cessna 152
Cessna 172S G1000

CIRRUS
Cirrus SR20

DIAMOND
Diamond DA20
Diamond DA40

PIPER
Piper Archer II (PA-28-181)
Piper Archer III (PA-28-181)
Piper Arrow (PA-28R-201)

More aircraft lessons are coming. Send an email to info@thebackseatpilot.com with suggestions.

II.E. Generic Flight Controls & Systems

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives

The learner should develop knowledge of the primary and secondary flight controls, and trim, as well as the aircraft's various systems and their operation.

Key Elements

1. Primary Flight Controls – Airflow and Pressure Distribution
2. Trim relieves control pressures
3. Flaps increase lift and induced drag

Elements

1. Terms
2. Primary Flight Controls
3. Secondary Flight Controls
4. Trim Systems
5. Powerplant
6. Ignition Systems
7. Induction Systems
8. Oil Systems
9. Cooling Systems
10. Exhaust Systems
11. FADEC
12. Propellers
13. Landing Gear & Brakes
14. Fuel Systems
15. Electrical Systems
16. Avionics
17. Flight Instruments
18. Environmental & Oxygen Systems
19. Deicing and Anti-Icing Systems
20. Autopilot
21. Abnormalities & Failures
22. Flight Instruction

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment

1. White board and markers
2. References

IP's Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP's Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards

The learner understands the operation of the flight controls and systems and has a foundation of knowledge in how the aircraft works and how it applies in real-life scenarios.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the flight controls and aircraft systems; to develop a better understanding of what is what, what is where, and why things work the way they do.

Overview

Review Objectives and Elements/Key ideas

What

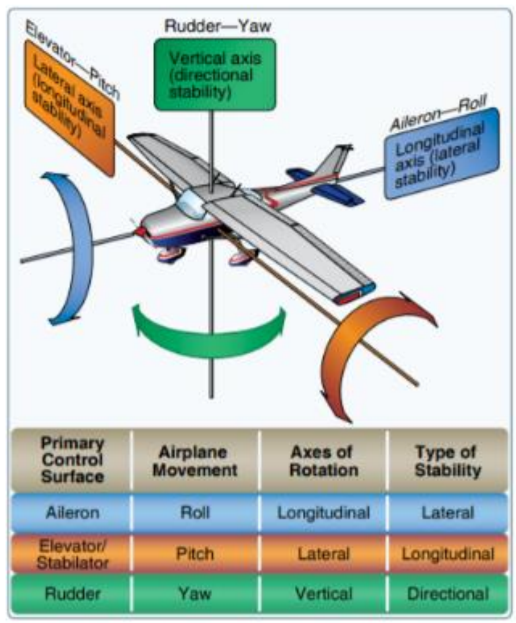
How the airplane's attitude is controlled using the primary flight controls. The effects and reasons for the secondary flight controls and trim, as well as the primary operating systems found on most aircraft.

Why

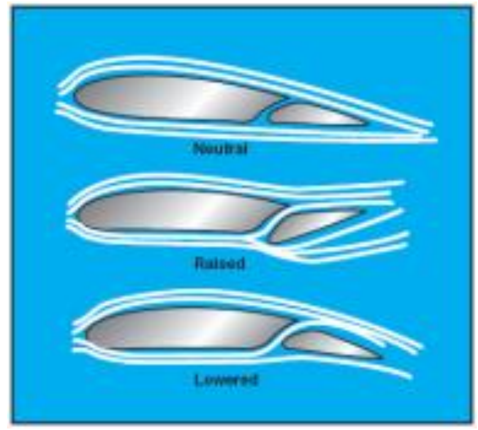
Understanding how the airplane functions results in an understanding of how to control the airplane, and a much more proficient pilot.

How:

1. **Terms**
   A. Chord Line – An imaginary straight line drawn through an airfoil from the leading to the trailing edge
   B. Camber – Characteristic curve of an airfoil's upper & lower surfaces
      i. Usually, the upper camber is more pronounced & lower camber is relatively flat
         a. Causes the velocity of the airflow immediately above the wing to be higher than below
      ii. The more curved the upper surface, the more lift is generated



2. **Primary Flight Controls** AI.II.E.K1a
   A. Primary flight controls are those required to safely control an airplane during flight
      i. Ailerons: Control roll about longitudinal axis
      ii. Elevator: Controls pitch about the lateral axis
      iii. Rudder: Controls yaw about the vertical axis
   B. Ailerons
      i. Control *roll* about the *longitudinal* axis
      ii. Operated by cables, bell cranks, pulleys and/or push-pull tubes connected to the control wheel or stick
      iii. How they Work
         a. Attached to the outboard trailing edge of each wing and move in opposite direction from each other
            - One goes up, the other goes down



- a In a right turn, the right aileron goes up and the left goes down
- b In a left turn, the left aileron goes up and the right goes down

b. The upward deflected aileron decreases the camber of the wing resulting in decreased lift causing the wing to lower

c. The downward deflected aileron increases the camber of the wing and results in increased lift causing the wing to raise

d. The increased lift on one wing, and decreased lift on the other wing cause the aircraft to roll

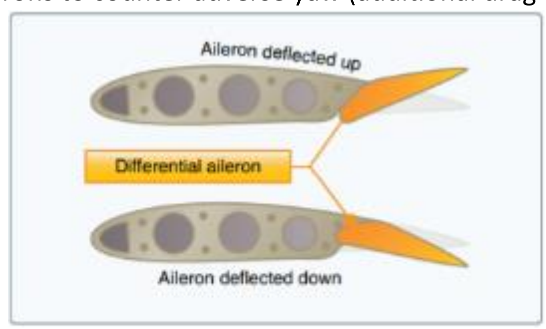
iv. Adverse Yaw

a. Since the downward deflected aileron produces more lift, it also produces more induced drag
- The added drag attempts to yaw the nose in the direction of the raised wing (Adverse Yaw)

b. Rudder must be used to counteract and maintain coordinated flight
- The amount needed is greatest at low speeds, high AOA, and with large aileron deflections

v. Types of Ailerons

a. Manufacturers have engineered four different types of ailerons to counter adverse yaw (additional drag due to the raised wing producing more lift)



b. Differential Ailerons
- Normally, ailerons moving an equal amount up and down during a turn
- Differential ailerons: upward moving aileron raises higher than the downward moving aileron lowers
  - a Ex: With full deflection in one direction, the upward aileron might move 15°, and the down aileron would only move 10°
- Produces increased drag on the descending wing (raised aileron) to counter adverse yaw
  - a Reduces, but doesn't eliminate, adverse yaw

c. Frise-Type Ailerons
- The raised aileron pivots on an offset hinge, projecting the leading edge of the aileron into the airflow which creates drag and reduces adverse yaw
- Also forms a slot so air flows smoothly over the lowered aileron, making it more effective at high angles of attack
- Reduces adverse yaw, but does not eliminate it

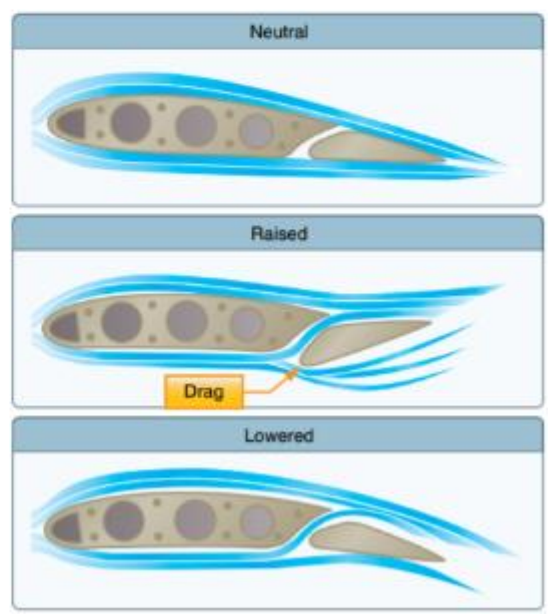


Figure 6-7. *Frise-type ailerons.*

d. Coupled Ailerons and Rudder
- The ailerons and rudder are linked with interconnect springs which automatically deflect the rudder at the same time the ailerons are deflected
  - a Ex: When rolling left, the interconnect cable and springs pull forward on the left rudder pedal just enough to prevent right yaw
- Rudder springs can be overridden by the pilot, if necessary

e. Flaperons

- Combine flaps and ailerons
- Control bank but can also be lowered together to function like a dedicated set of flaps
    - a Separate controls for ailerons and flaps
    - b A mixer is used to combine the separate pilot inputs into the single set of control surfaces
- Often mounted away from the wing to provide undisturbed airflow at high angles of attack and/or low airspeeds

Figure 6-9. *Flaperons on a Skystar Kitfox MK 7.*

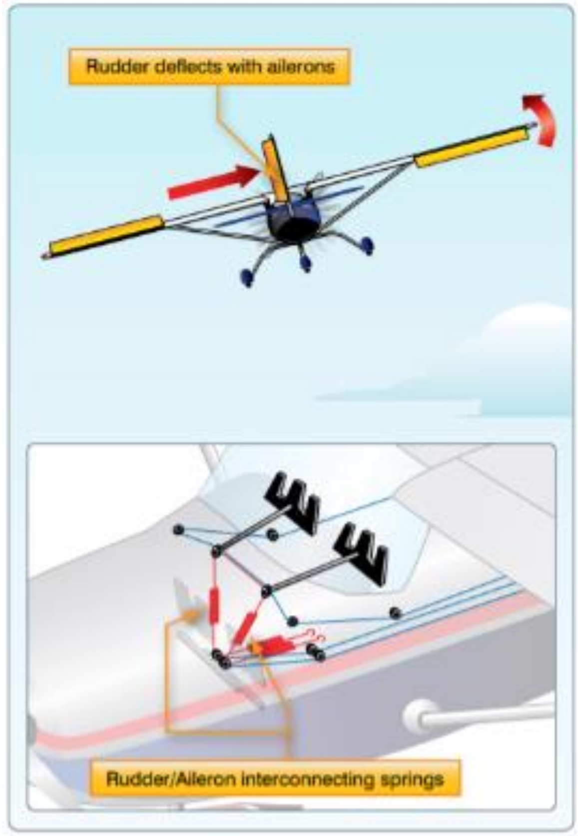
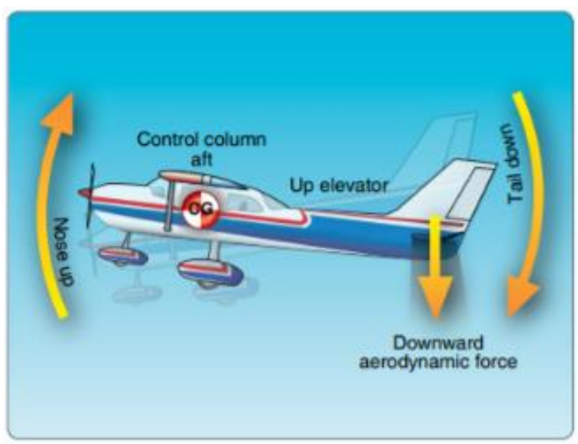


Figure 6-8. *Coupled ailerons and rudder.*

C. Elevator
   i. Controls *pitch* about the *lateral* axis
   ii. Like ailerons, operated by a series of mechanical linkages
   iii. How It Works
      a. Pulling the controls backward deflects the trailing edge up
         - Changes the camber of the horizontal stabilizer, creating a downward aerodynamic force
         - The overall effect causes the tail to move down and the nose to move up (about the CG)
            - a Strength is determined by the distance between the CG and horizontal tail surface



      b. Moving the controls forward deflects the trailing edge of the elevator surface down
         - Changes the camber of the horizontal stabilizer, creating an upward force
         - Moves the tail upward, pitching the nose down (also about the Center of Gravity)
   iv. Types of Elevators
      a. T-Tail
         - Elevator is mounted at the high point of the vertical stabilizer and is above most effects of downwash from the propeller and airflow around the fuselage and wings in normal flight
            - a Makes for consistent control movements in most flight regimes
         - Popular on light, as well as large airplanes (removes elevator from exhaust), and sea planes
         - Control Differences
            - a At slow speeds, the elevator must be moved through a larger number of degrees to raise the nose a given amount as compared to a conventional tail aircraft

1. The conventional tail has the downwash from the propeller to assist in raising the nose

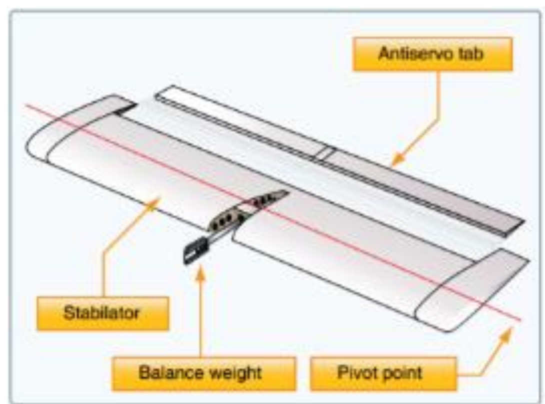
- The controls are rigged so that increased control force is required the farther the controls move
  a It gets progressively more difficult to move the elevator

b. Design Considerations

- Since the weight of the horizontal stabilizer is at the top of the vertical stabilizer, the moment arm created causes high loads on the vertical stabilizer that can result in flutter
  a Engineers must compensate for this by increasing the design stiffness of the vertical stabilizer, usually resulting in a weight penalty over conventional designs
- When flying at a very high angle of attack with a low airspeed and aft center of gravity, the T-tail may be more susceptible to a deep stall
  a The wake of the wing impinges on the tail surface and renders it almost ineffective
  b The wing's airflow, when fully stalled, creates a wide wake of decelerated, turbulent air that blankets the horizontal tail
    1. Elevator control is reduced, or possibly eliminated, making it difficult to recover from the stall

c. Stabilator

- "All-moving tail." A fully movable aircraft stabilizer
- A one-piece horizontal stabilizer that pivots from a central hinge point
  a When the controls are pulled back, the stabilator's trailing edge raises, rotating the nose up
  b Pushing forward lowers the trailing edge and pitches the nose down
- Antiservo tabs on the trailing edge decrease sensitivity
  a Because a stabilator pivots around a central hinge point, it allows the pilot to generate a given pitching moment with lower control force
    1. Because they are easier to move, to be certified an aircraft must show an increasing resistance to increasing pilot input
    2. To provide this resistance, stabilators on small aircraft contain an anti-servo trim tab that deflects in the same direction as the stabilator, providing an aerodynamic force resisting the pilot's input and making it less prone to overcontrolling



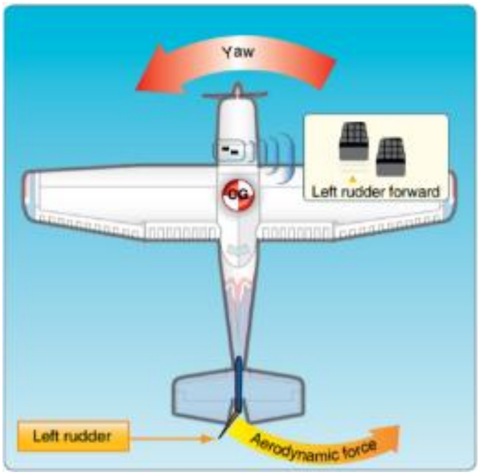
v. Safety Systems

a. Since flight at high AOAs can be dangerous, many aircraft compensate for these situations

- Systems range from control stops to elevator down springs
  a Control stops limit the movement of the elevator control
    1. Some stops can adjust to allow more/less elevator control movement based on the situation
  b Elevator down spring: assists in lowering the nose of the aircraft to prevent a stall caused by an aft CG position
    1. Produces a mechanical load on the elevator causing it to move toward the nose-down position, if not otherwise balanced
- Stick pushers are commonly used on transport category jets

        a If the computers recognize an approaching or impending stall, they will automatically push forward on the stick to prevent reaching a critical angle of attack

D. Rudder
  i. Controls *yaw* about the *vertical* axis
    a. Typically used to maintain coordination
  ii. Often cable operated, but can be operated by various mechanisms
  iii. How it Works
    a. When the rudder is deflected into the airflow, a horizontal force is exerted in the opposite direction
      - Pushing the left pedal moves the rudder left
        a Alters airflow around the vertical stabilizer creating a sideward lift moving the tail right & nose left
          1. Moving the rudder in either direction increases the camber and therefore increases lift on one side of the rudder. Additionally, pushing the rudder into the relative wind creates a force which moves the aircraft's nose in the same direction



    b. Rudder effectiveness increases with speed
      - Large deflections may be necessary at low speeds and small deflections at high speeds
      - In a propeller driven airplane, any slipstream flowing over the rudder increases effectiveness
  iv. V-Tail
    a. Utilizes two slanted tail surfaces to perform the same functions as a conventional elevator and rudder
      - The fixed surfaces act as both horizontal and vertical stabilizers
    b. The movable portion of the V-tail, often called ruddervators, are connected through a special linkage that allows the control wheel to move both surfaces simultaneously
      - Moving the rudder pedals moves the surfaces differentially, providing directional control
      - When both the rudder and elevator are moved, a control mixing mechanism moves each surface the appropriate amount
    c. Drawbacks
      - More complex than for a conventional tail
      - More susceptible to Dutch roll
      - Total reduction in drag is minimal

Figure 6-16. *Beechcraft Bonanza V35.*

3. Secondary Flight Controls AI.II.E.K1b

A. Secondary control systems improve performance characteristics or relieve excessive control forces
  i. Flaps, leading edge devices, spoilers and trim systems
    a. We'll focus on the more common items – wing flaps, spoilers, and trim

B. Flaps
  i. The most common high lift devices used on practically all airplanes
    a. Attached to the trailing edge of each wing to increase induced drag and lift for any given AOA
    b. Important Functions
      - Increased lift allows the aircraft to get airborne at lower speeds, reducing the amount of runway required, and improves climb performance
      - The increased drag allows for steeper approaches
        a A great example of this are military aircraft, specifically C-130s and C-17s, which can use flaps to

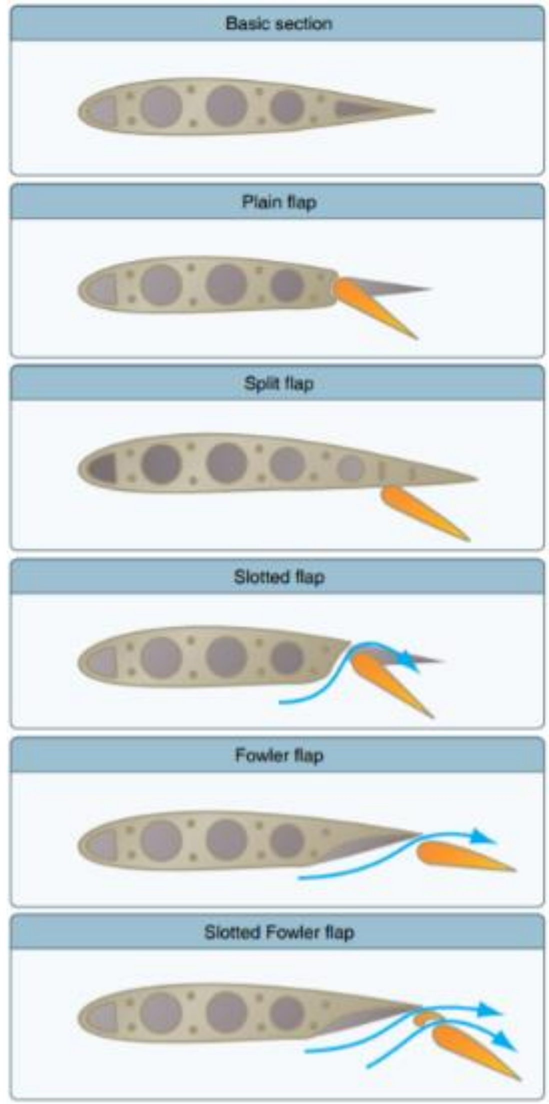
their advantage to perform steep approach and landings

- The lower landing speeds provide shorting landing distances
- Although many of these factors don't have a huge impact on general aviation aircraft, these functions make large differences for airliners which would otherwise need tremendous amounts of runway to takeoff and land

ii. Plain Flaps
   a. Simplest of the types
   b. Increase wing camber, resulting in a significant increase in the coefficient of lift at a given AOA
   c. Drag is greatly increased, and the center of pressure moves aft resulting in a nose down pitching moment

iii. Split Flaps
   a. Deflect from the lower surface and produce a slightly greater increase in lift than the plain flap
   b. More drag is produced because of the turbulent airflow behind the airfoil

iv. Slotted Flap
   a. Most popular on airplanes today
   b. Increase lift significantly more than plain and split flaps
   c. When lowered, it forms a duct between the flap well in the wing, and the flap's leading edge
      a High energy air from the lower surface is ducted to the upper surface accelerating the upper boundary layer and delaying airflow separation
   d. Large aircraft have double- or even triple-slotted flaps
      - Allows for maximum increase in drag without destroying the flap's added lift



v. Fowler Flaps
   a. Type of slotted flap which changes the camber of the wing and increases the wing area
   b. Slides backward on tracks and then retracts downward
   c. First portion of extension greatly increases lift with a very small increase in drag
      - As extension continues and the flap drops downward, drag increases with little increase in lift

vi. Flap Control
   a. Mechanically, electrically, or hydraulically operated
      - Can also be a combination
         a For example, many flaps are electrically powered and hydraulically actuated
         b An electric switch activates the hydraulic pump(s) which physically move the flaps
   b. Be aware of any flap operating speeds for your particular aircraft

C. Spoilers
   i. High drag devices deployed from the wings to spoil the smooth airflow over the wing, reducing lift and increasing drag
   ii. Uses
      a. Reduce Airspeed
         - Increased drag allows for a more rapid reduction of airspeed in flight, and decreases ground roll

during landing

a On landing, airspeed decreases due to the spoilers being raised, and the destruction of lift transfers the weight from the wings to the wheels, improving braking effectiveness

b. Increased Rate of Descent

- The aircraft can descend at a faster rate without increasing airspeed

c. Roll control

- To turn, the spoiler on one of the wing's is deployed destroying some of the lift and creating more drag on that wing

  a The wing with the spoiler deployed will drop and the aircraft banks and yaws in that direction

  b Adverse yaw is eliminated

4. Trim Systems

A. Used to relieve the need to maintain constant pressure on the flight controls

B. Consist of flight deck controls and small hinged devices on the trailing edge of one or more primary control surfaces

i. Minimize workload by aerodynamically assisting movement and the position of the controls

C. How a Trim Tab Works

i. The most common installation is a single trim tab attached to the trailing edge of the elevator

ii. Operation

a. Often operated manually through a small, vertically mounted control wheel (or trim crank)

b. The trim tab moves in the opposite direction of the elevator surface

c. Placing the trim in full nose-down moves the tab to its full up position (pictured, right)

- With the tab up, into the airstream, airflow over the tail forces the elevator down

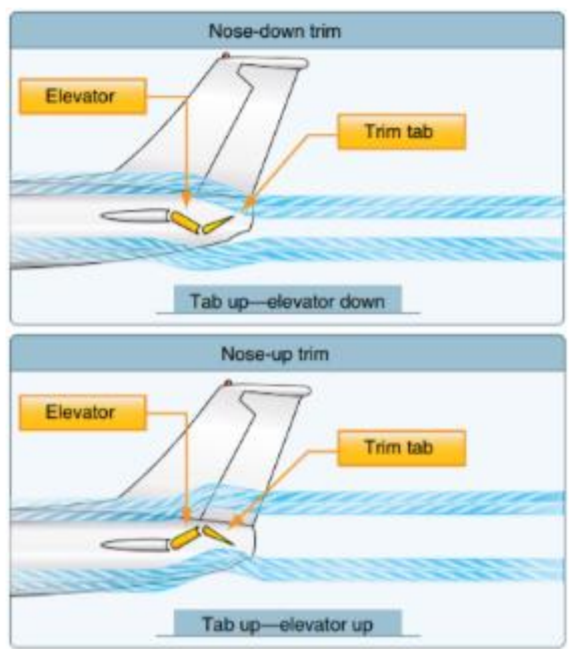
  a Causes the tail to move up and results in a nose-down pitch change

d. In the full nose-up position, the tab moves to its full down position (pictured, right)

- Air flowing under the tail hits the tab forcing the elevator up, reducing the elevator's AOA

  a Causes the tail to move down and results in a nose-up pitch change

- Note: The bottom picture says "Tab up," but should say "Tab down"



D. Types of Trim Tabs

i. Balance Tabs

a. Look and function just like trim tabs, but the balance tab is coupled to the control surface rod

- When the controls are deflected, the tab automatically moves in the opposite direction

  a Any time the control surface is deflected, the tab moves the opposite direction

  b Airflow against the tab counterbalances some of the air pressure against the control surface enabling the pilot to move the control more easily and hold the control surface in position

b. If the linkage is adjustable from the flight deck, the tab acts as both a trim and balance tab

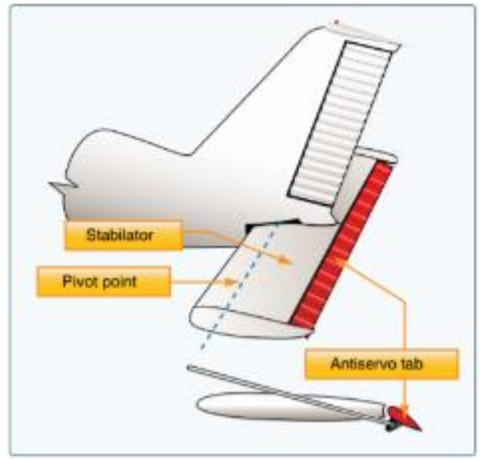
ii. Servo Tabs (primarily used in large aircraft)

a. Vey similar in operation and appearance to trim tabs and balance tabs

b. A servo tab is a small portion of a flight control that deploys in such a way that it helps to move the

entire flight control surface in the direction that the pilot wishes it to go
  c. Aids in moving the control surface and holding it in the desired position
  d. Only the servo tab moves in response to movement of the flight controls
    - The force of the airflow on the servo tab then moves the control surface

iii. Antiservo Tabs
  a. Decrease stabilator sensitivity and act as a trim device
  b. Operation
    - Work the same as a balance tab, but it moves in the same direction as the flight control (rather than opposite)
    - When the trailing edge of the stabilator moves up, the trailing edge of the tab moves up



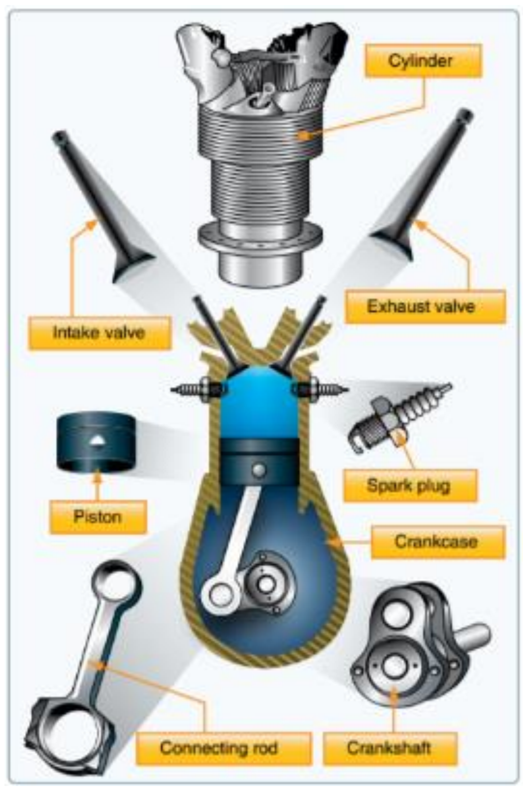
iv. Ground Adjustable Tabs
  a. Metal trim tab on the rudder bent in either direction while on the ground to apply a trim force
    - Displacement is found through trial and error

v. Adjustable Stabilizer
  a. Instead of using a trim tab on the elevator, some aircraft can adjust the entire stabilizer
    - This is driven by a jackscrew (motor driven on large aircraft and cranked on small aircraft)

E. Using Trim Tabs
  i. Establish the desired power, pitch attitude, and configuration, then trim to relieve pressures
  ii. Any time power, pitch attitude, or configuration is changed, re-trim for the new condition

5. **Powerplant** – four-stroke, reciprocating engines AI.II.E.K1c

A. General
  i. Four stroke, reciprocating engine is the most common design used in general aviation
  ii. The name is derived from the back-and-forth, or reciprocating, movement of the pistons
  iii. Basic Operating Principle - Convert chemical energy (fuel) into mechanical energy
    a. Pistons produce the mechanical energy to accomplish work
    b. Occurs in the engine cylinders through combustion



B. Basic Components and Operation
  i. Components
    a. Cylinders
      - Contain intake/exhaust valves, sparks plugs and pistons
        a Intake and exhaust valves allow the fuel-air mixture to enter the combustion chamber of the cylinder, and the burned gases to exit
        b Spark plugs are used to ignite the fuel air mixture
          1. Some engines do not have spark plugs, but use high pressure to ignite the fuel-air mixture
        c The pistons move up and down in the cylinder and drive the crankshaft which drives the propeller
    b. Crankcase
      - Contains crankshaft, and connecting rods

- a The pistons are connected to the crankshaft via the connecting rods
- b The movement of the pistons through the connecting rods rotate the crankshaft
  1. The connecting rods transfer the linear (up and down) motion of the cylinders to rotational motion, or the spinning of the crankshaft
- c The crankshaft is connected to the propeller

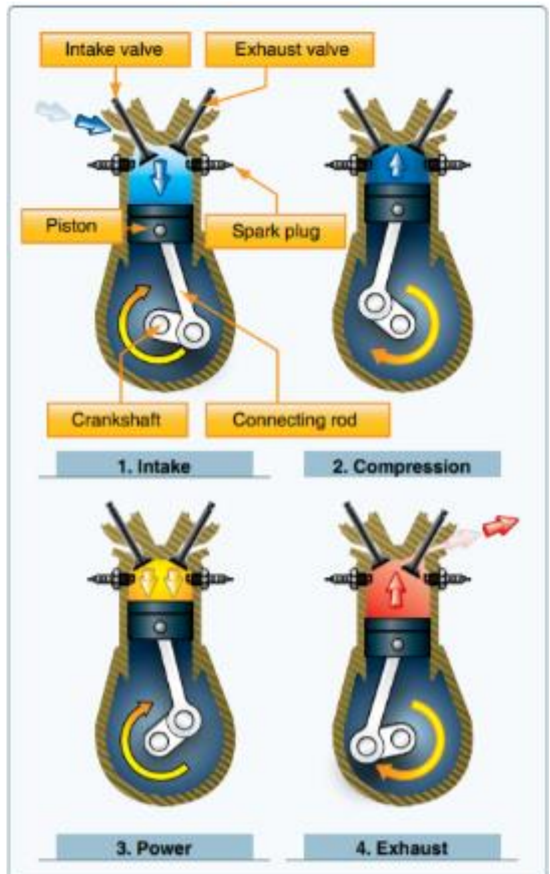
c. Accessory Housing
- Contains magnetos, if applicable
  - a Magnetos are the power source for the spark plugs
    1. As mentioned above, some airplanes do not use spark plugs and rely on compression alone
    2. More information in the next section, Ignition System

ii. Four-stroke operating cycle

a. Intake Stroke
- The fuel-air mixture is pulled into the combustion chamber of the cylinder
  - a Piston moves to the bottom, increasing the volume in the chamber
  - b The fuel air mixture enters the combustion chamber

b. Compression Stroke
- The fuel-air mixture is compressed as the piston moves up, decreasing the volume in the chamber
  - a Intake valve closes
  - b Piston moves to the top, compressing the fuel-air mixture
  - c At the end of this stroke, a spark plug ignites the mixture

c. Power Stroke
- The fuel-air mixture is ignited, increasing pressure and forcing the piston back down
  - a Begins when the fuel-air mixture is ignited resulting in a tremendous increase in pressure
    1. Forces the piston back down, away from the cylinder head
    2. This creates the power that turns the crankshaft which drives the propeller



d. Exhaust Stroke
- The burned gases are expelled
  - a The exhaust valve opens as the piston reaches the bottom
  - b As the piston moves back up, it pushes out the exhaust gases

C. Two Primary Engine Designs

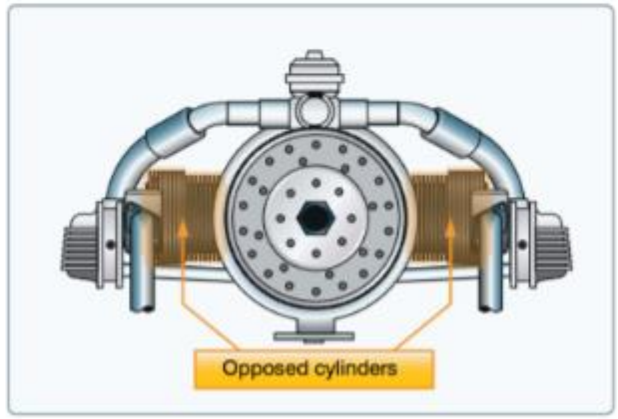
i. Spark Ignition and Compression Ignition

a. Spark ignition (contains spark plugs/magnetos), has been the most popular choice for many years

b. In an effort to reduce costs, simplify design, and improve reliability, several manufacturers are turning to compression ignition systems
- Compression systems can run on diesel or jet fuel
- Diamond DA42, for example
  - a Runs on jet fuel, and uses compression ignition

ii. Components
   a. The main mechanical components of spark and compression systems are essentially the same
   b. The main difference is the process of igniting the fuel
      - Spark Ignition – uses a spark plug to ignite a pre-mixed fuel air mixture
      - Compression Ignition – compresses the air in the cylinder, raising its temperature to a degree necessary for automatic ignition when fuel is injected into the cylinder
         a Higher pressure = higher temperatures

D. Horizontally Opposed Cylinder Arrangement
   i. The most popular reciprocating engine for smaller aircraft
   ii. Cylinders oppose each other
      a. A cylinder on one side of the crankcase "opposes" a cylinder on the other
      b. For this reason, they always have an even number of cylinders
   iii. Generally air cooled and mounted in a horizontal position
   iv. Compact cylinder arrangement reduces the engine's frontal area and allows a streamlined installation minimizing aerodynamic drag
   v. High power-to-weight ratios
      a. Due to comparatively small, lightweight crankcase



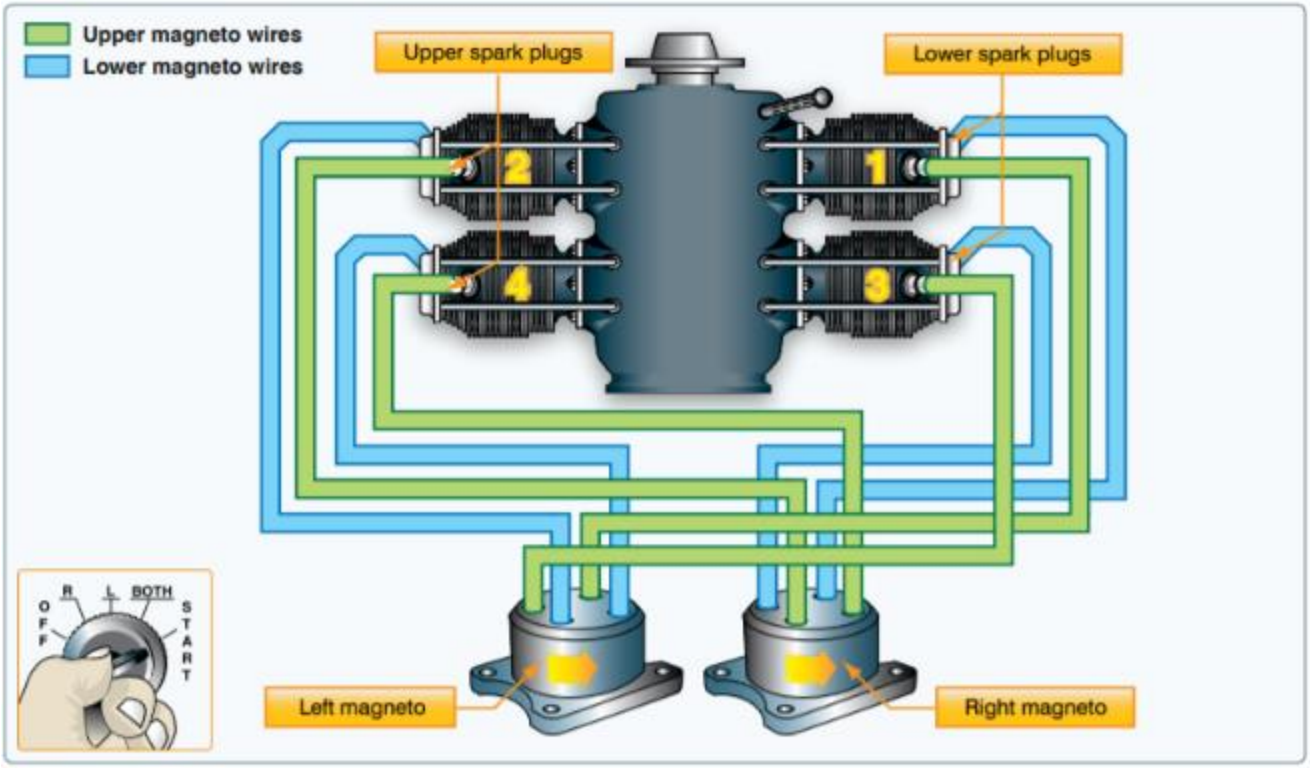
6. Ignition System

A. General
   i. The ignition system provides a spark that ignites the fuel-air mixture in the cylinders

B. Components
   i. Magnetos
      a. A self-contained, engine driven unit that supplies electrical current to the spark plugs; completely independent of the airplane's electrical system
         - A permanent magnet is used to generate the electrical current
         - If the airplane loses electrical power (alternator and battery failure), the magnetos continue operating and the engine will continue to run
      b. Normally there are two magnetos per engine (a left and a right)
   ii. Spark Plugs
      a. The device that delivers electric current from the magnetos to the combustion chamber to ignite the fuel-air mixture
         - Basically, takes the energy from the magneto and delivers it as a spark in the combustion chamber
   iii. High-Tension Leads
      a. The wires that connect the magnetos to the spark plugs
   iv. Ignition Switch
      a. Controls the operation of the magnetos
      b. 5 position switch:
         - Off
         - R (right) - Only runs the R magneto
         - L (left) - Only runs the L magneto
         - Both - Runs on both magnetos
         - Start - Engages the starter using battery power. The starter rotates the crankshaft

a The ignition system begins to fire when the starter is engaged and the crankshaft begins to turn

C. Operation



i. Normal Operation
   a. The system begins to fire when the starter is engaged and the crankshaft begins to turn
      - The starter and initial crankshaft rotation are powered by the battery
   b. The rotation of the crankshaft activates the magnetos which generate high voltage to produce a spark through the spark plugs in the combustion chamber
      - The combustion in the chamber produces piston movement which rotates the crankshaft
   c. Once the engine can move the pistons on its own, then engine is started and the starter is no longer necessary
      - The starter is disengaged and the system operates on its own
      - As long as the crankshaft is rotating, the magnetos/ignition system continue to operate
      - As long as the magnetos/ignition system continue to operate, the crankshaft continues rotating
      - Battery power is no longer necessary for engine operation

ii. Dual Ignition System
   a. Most general aviation aircraft use a dual ignition system containing two individual magnetos, separate sets of wires, and two separate spark plugs in each cylinder
   b. Each magneto operates independently to fire one of the two spark plugs in each cylinder
      - Firing two spark plugs in each cylinder improves combustion and results in a slightly higher power output
      - If one magneto were to fail, the other is unaffected and the engine continues to operate normally, but with a slight decrease in power
         a The same is true if one of the two spark plugs in a cylinder fails

7. Induction Systems

A. General

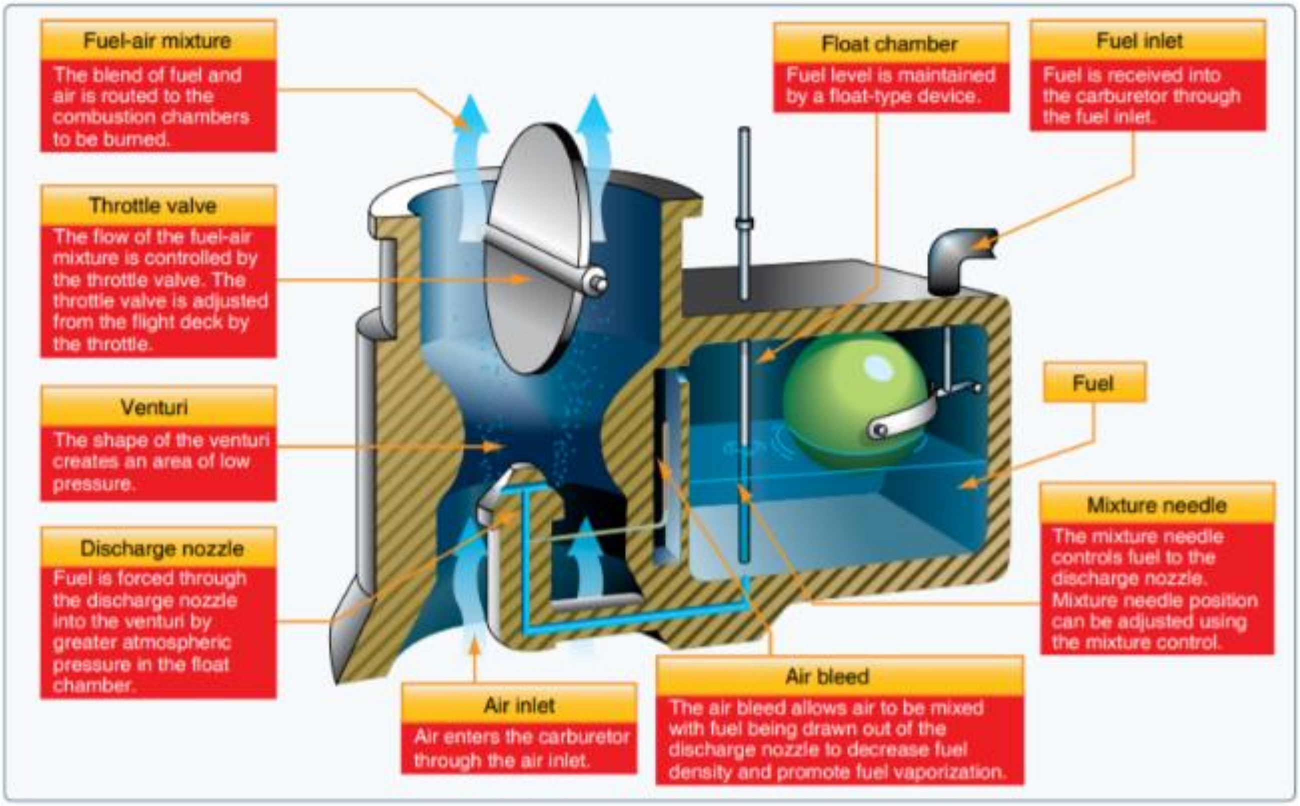
i. Brings in air from the outside, mixes it with fuel, and delivers the fuel-air mixture to the cylinders

a. Air enters through an intake on the front of the engine and then travels through an air filter to prevent dust and debris from entering the engine
b. Since the filter may become clogged, an alternate air source must be available
   - This alternate source of air usually comes from inside the engine cowling, where it bypasses the filter

ii. Two types of induction systems
   a. Fuel Injection System
      - Mixes the fuel and air immediately before entry into each cylinder, or injects fuel directly into each cylinder
   b. Carburetor System
      - Mixes the fuel and air in the carburetor before it enters the intake manifold

B. Carburetor System
   i. General
      a. Mixes the fuel and air in the carburetor before entering the intake manifold
      b. Two categories of carburetors – Float-type and pressure-type
         - Float-type are the most common
         - Pressure-type are rarely found in small aircraft
         - The basic difference is the delivery of fuel – the pressure type carburetor delivers fuel under pressure by a fuel pump
   ii. Float-type Carburetors
      a. Operation
         - Fuel is sent from the fuel tank(s) to the carburetor float chamber
         - The float chamber stores and meters the fuel that will be mixed with the air and sent to the engine
            a The float chamber consists of a float that rests on the fuel in the chamber and a needle which is attached to the float
               1. The needle opens and closes an opening at the bottom of the chamber. When opened, fuel is sent through the carburetor
         - Based on the position of the float and the needle, fuel is metered to the discharge nozzle where it will be mixed with the air
            a When the level of fuel in the float chamber forces the float to rise, the needle valve closes the fuel opening and stops fuel to the carburetor.
            b The needle valve opens again when the engine requires additional fuel
            c The position of the mixture needle is controlled by the mixture control lever in the flight deck
         - At the same time, outside air enters through an air filter
         - The filtered air flows into the carburetor and through a venturi (narrow throat in the carburetor)
            a When the air flows through the venturi, a low-pressure area is created that forces fuel to flow through a main fuel jet located at the throat
               1. This is the fuel that was allowed into the carburetor when the needle valve opened
         - The fuel and air are mixed and flow to the combustion chambers based on the position of the throttle valve
            a The throttle valve is controlled by the throttle
            b Increasing power opens the valve, allowing more of the fuel-air mixture to the combustion chambers

c Closing the throttle closes the valve, reducing the fuel-air mixture to the combustion chambers



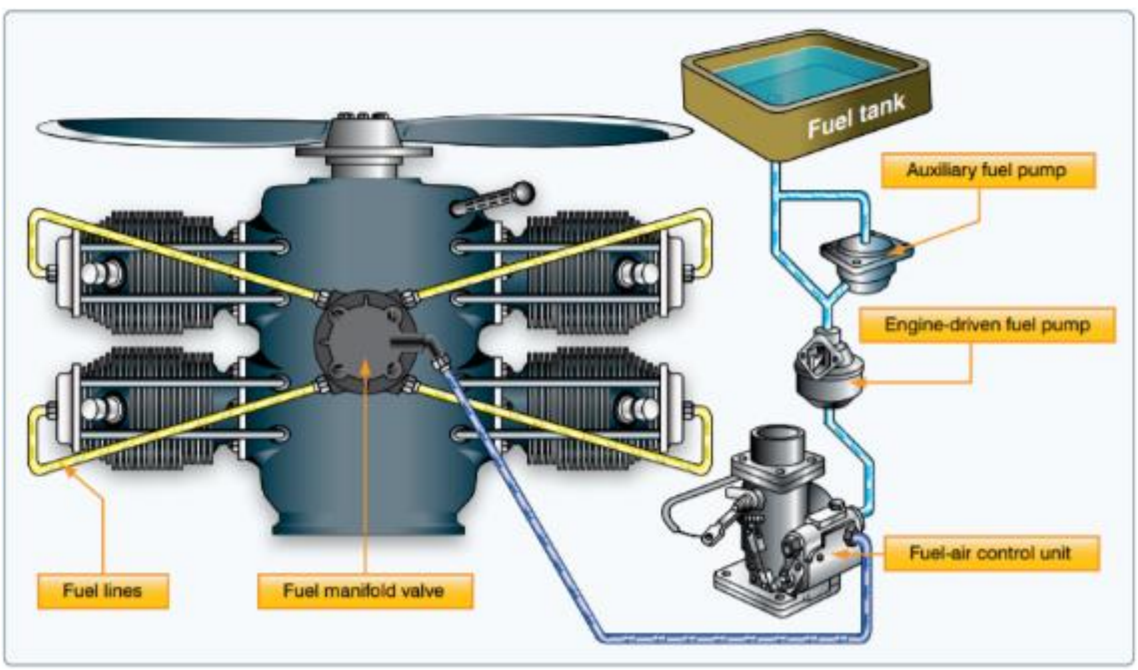
b. Disadvantages
- Do not function well with abrupt maneuvers
- The discharge of fuel at low pressure leads to incomplete vaporization and difficulty in discharging fuel into some types of supercharged systems
- Chief Disadvantage - Icing tendencies

c. Carburetor Icing
- Occurs due to the effect of fuel vaporization and the decrease in air pressure in the venturi, which causes a sharp drop in temperature in the carburetor
  - a If water vapor in the air condenses when the carburetor temperature is at or below freezing, ice can form on the internal surfaces of the carburetor, including the throttle valve
    1. Ice generally forms in the vicinity of the throttle valve and in the venturi throat
- Carburetor icing restricts the flow of the fuel-air mixture and reduces power
  - a If enough ice builds up, the engine can stop operating
- Most likely to occur at temperatures below 70° F with relative humidity greater than 80%
  - a Due to the sudden cooling, icing can occur at temperatures as high as 100° F and humidity as low as 50%
- The first indication of carburetor icing in an aircraft with a fixed pitch propeller is a decrease in rpm, which may be followed by engine roughness
  - a In an aircraft with a constant-speed propeller, carburetor icing is usually indicated by a decrease in manifold pressure, but no reduction in rpm
    1. In this case, the pitch is automatically adjusted to maintain rpm
- Carburetor heat is used to combat carburetor icing

d. Carburetor Heat

- Anti-icing system that preheats the air before it reaches the carburetor
  - a Intended to keep the fuel-air mixture above freezing
- Primary use is to prevent the formation of ice, but can be used to melt ice that has already formed, if the accumulation is not too great
- The use of carb heat decreases engine power, sometimes up to 15%
  - a Heated air is less dense than the outside air that was being used leading to reduced performance
    1. Using carb heat enriches the mixture (same fuel with less dense air)
    2. Because it reduces engine output, carb heat should not be used when full power is required. Follow the POH

C. Fuel Injection System
   i. General
      a. Fuel is injected directly into the cylinders, or just ahead of the intake valve
      b. Advantages of Fuel Injection
         - Reduction in evaporation icing
         - Better fuel flow
         - Faster throttle response
         - Precise control of mixture
         - Better fuel distribution
         - Easier cold weather starts
      c. Disadvantages of Fuel Injection
         - Difficulty in starting a hot engine
         - Vapor locks during ground operation on hot days
         - Problems associated with restarting an engine that quits because of fuel starvation



   ii. Components and Operation
      a. Engine-driven fuel pump
         - Provides fuel to the fuel-air control unit after the engine is started
      b. Auxiliary fuel pump

- Provides fuel under pressure to the fuel-air control unit for engine starting and/or emergency use (loss of the engine driven pump)

c. Fuel-air control unit
   - Meters fuel based on the mixture control setting and sends it to the fuel manifold valve at a rate controlled by the throttle
   - Basically, replaces the carburetor

d. Fuel manifold (distributor)
   - Distributes the fuel to the individual fuel discharge nozzles

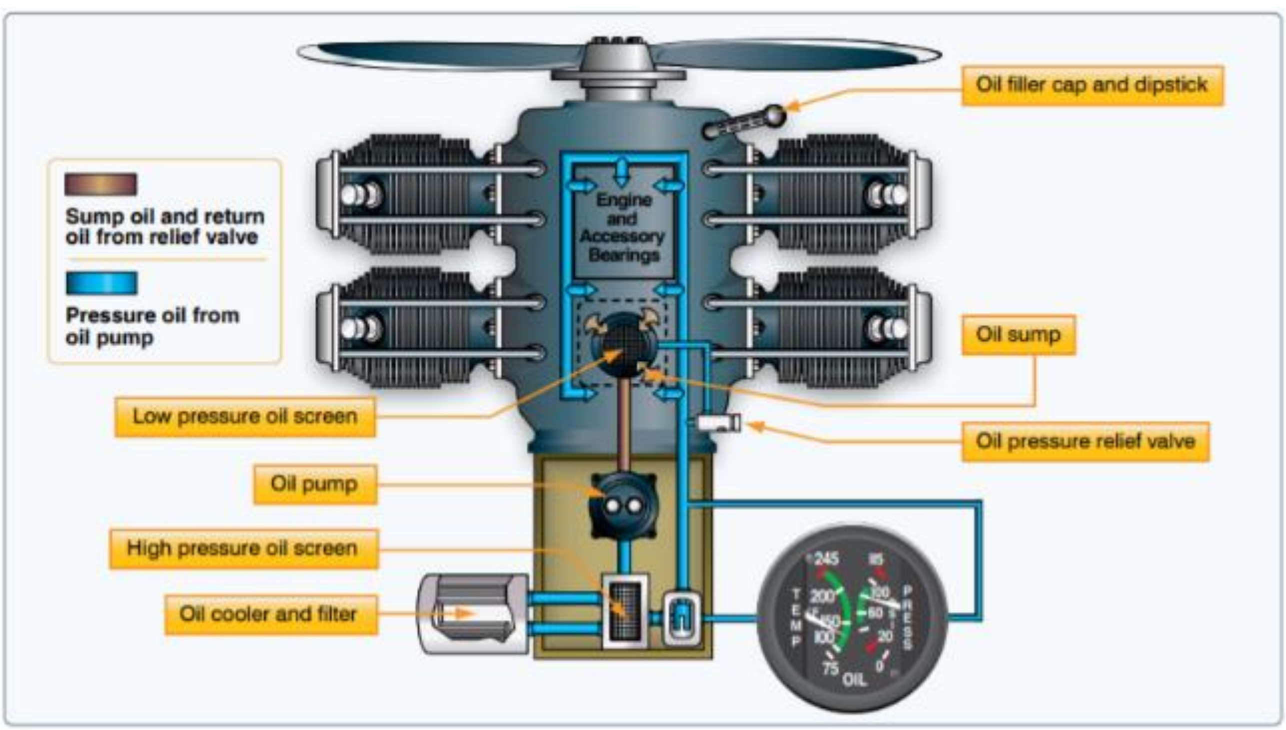
e. Discharge nozzles
   - Located in the cylinder heads, and inject the fuel-air mixture directly into each cylinder intake port

f. Fuel pressure/flow indicators
   - Provide the pilot information in regard to the fuel system

8. Oil Systems

A. Functions of the Oil System
   i. Lubricates the engine's moving parts
   ii. Cools the engine by reducing friction and removes heat from cylinders
   iii. Provides a seal between the cylinder walls and pistons
   iv. Carries away contaminants

B. Types of Oil Systems
   i. Wet-Sump System
      a. Oil is in a sump that is an integral part of the engine (usually located at the base of the engine)
      b. Operation
         - The oil pump draws oil from the sump and routes it to the engine
         - After oil passes through the engine, it returns to the sump
            a Generally returned by gravity to the sump since the sump is located at the bottom of the engine
         - In some engines, additional lubrication is supplied by the rotating crankshaft, which splashes oil onto portions of the engine



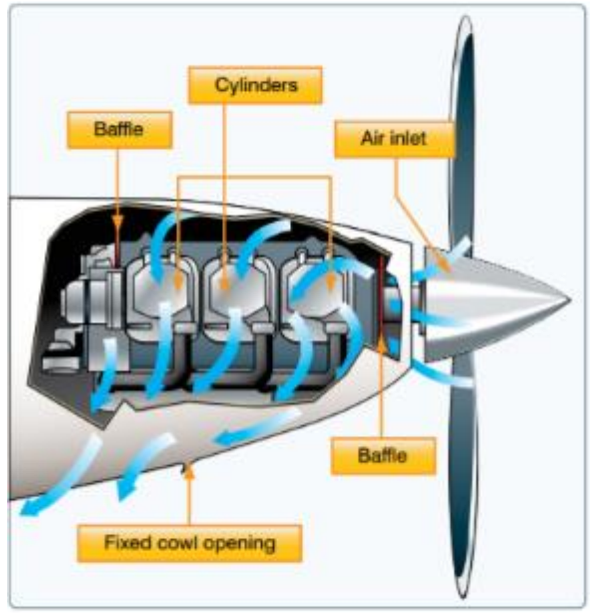
ii. Dry-Sump System
  a. Oil is contained in a separate tank, outside of the engine, and circulated through the engine by pumps
  b. Allows for a greater volume of oil to be supplied to the engine (useful for large reciprocating engines)
  c. Operation
    - An oil pump supplies oil pressure to pump oil from the external oil tank through the engine
    - After oil is route through the engine, it is pumped from various locations in the engine back to the oil tank by scavenge pumps

C. Indications
  i. Oil Pressure Gauge
    a. Provides a direct indication of the oil system operation
    b. Ensure the pressure in pounds per square inch (psi) of the oil supplied to the engine
  ii. Oil Temperature Gauge
    a. Measures the temperature of the oil
      - Unlike oil pressure, temperature changes occur more slowly
    b. High oil temperatures may signal:
      - A plugged oil line
      - Low oil quantity
      - A blocked oil cooler
      - A defective temperature gauge
    c. Low oil temperatures may signal:
      - Improper oil viscosity during cold weather operations

9. Cooling Systems

A. General
  i. Why cooling is needed
    a. The burning of fuel in the cylinders produces intense heat, most of which is expelled through the exhaust system
    b. Much of the remaining heat must be removed, or at least dissipated, to prevent the engine from overheating
      - Otherwise, the extremely high engine temperatures can lead to loss of power, excessive oil consumption, detonation, and serious engine damage
    c. The oil system is vital to the internal cooling of the engine, additional external cooling is necessary
  ii. Types of engine cooling
    a. Air Cooling
      - Most small aircraft are air cooled – this is they system we'll focus on
      - Air flows into the engine compartment where it's routed over the hottest parts of the engine and expelled through the lower, aft portion of the cowling
    b. Liquid Cooling
      - Cooling liquid (usually water, ethylene glycol, or a combination of the two) is pumped around the engine to cool the hot components
        a Like the cooling system in your car
      - Primary benefits: Less chance of shock cooling & the ability to direct coolant to specific, critical areas
      - Negatives include added weight, and increased complexity (and increased cost)

B. Air Cooling
  i. Operation



a. Outside air enters the engine compartment where baffles direct it to the hottest parts of the engine, primarily the cylinders, which have fins that increase the area exposed to the airflow
b. Air cooling is dependent on air flow, therefore it is less effective during ground operations, takeoffs, go-arounds, and other instances of high-power, low-airspeed operation
   - Conversely, high-speed descents provide excess air and can shock cool the engine, subjecting it to abrupt temperature fluctuations

ii. Monitoring and Controlling Engine Temperature
   a. Monitoring Temperature
      - The oil temperature gauge gives an indirect and delayed indication of rising engine temperature
         a Can be used for determining engine temperature if this is the only means available
      - Cylinder head temperature (CHT) indicates a direct and immediate cylinder temperature change
   b. Controlling Temperature
      - To avoid excessive cylinder head temperatures:
         a Increase airspeed,
         b Enrich the fuel air mixture, and/or
         c Reduce power
         d Open cowl flaps (if installed)

10. Exhaust Systems

A. Operation and Uses
   i. Engine exhaust systems vent the burned combustion gases overboard, provide heat for the cabin, and defrost the wind screen
   ii. Operation
      a. Engine Exhaust
         - After combustion, the exhaust gases are pushed out of the cylinder through the exhaust valve and travel through the exhaust manifold/piping, and muffler to the atmosphere
      b. Cabin Heat
         - Outside air is drawn into the air inlet and is ducted through a shroud around the muffler
            a The muffler is heated by the exiting exhaust gases, and in turn heats the air around the muffler
         - The heated air is ducted to the cabin for heat and defrost
         - Exhaust gases contain large amounts of carbon monoxide which is odorless and colorless, and deadly
            a To ensure exhaust gases are properly expelled, and not brought into the cabin through the heating system, the exhaust must be in good condition and free of cracks

B. EGT
   i. Some exhaust systems have an Exhaust Gas Temperature (EGT) probe
      a. An EGT probe measures the temperature of the gases at the exhaust manifold
   ii. The temperature of the gases varies based on the ratio of fuel to air entering the cylinders and can be used as a basis for regulating the fuel-air mixture
      a. The EGT gauge is highly accurate in indicating the correct fuel-air mixture setting

b. For specific procedures, reference the POH

11. FADEC (Full Authority Digital Engine Control)

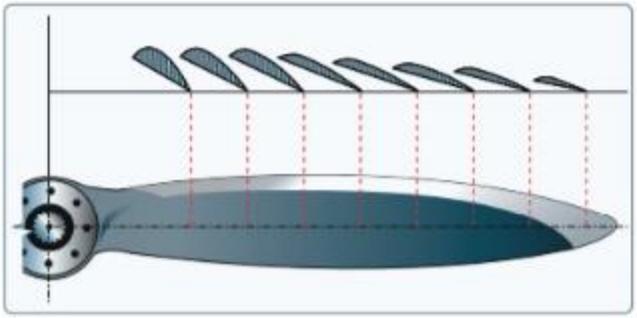
A. System consisting of a digital computer and ancillary components that control an aircraft's engine and propeller
   i. First used in turbine aircraft, they are increasingly being used in piston powered aircraft (ex. Diamond DA42)

B. What it does
   i. Optimizes performance
      a. The FADEC uses speed, temperature, and pressure sensors to monitor the status of each cylinder
      b. A digital computer calculates the ideal pulse for each injector, and adjusts ignition timing, and fuel flow as necessary
         - Generally, results in decreased fuel consumption and increased horsepower
   ii. Simplifies the Systems
      a. Eliminates need for magnetos, carburetor heat, mixture controls, propeller controls, and engine priming
      b. A single throttle is characteristic of FADEC equipped aircraft
         - The pilot simply sets the throttle position, and the computer does the rest
            a There is no need to monitor or control the mixture setting, or propeller

C. Safety
   i. The FADEC is an essential part of the engine and propeller controller. Losing this system could result in complete loss of engine power
   ii. To prevent a failure from resulting in engine failure,
      a. There must be a backup electrical source available
      b. Two separate and identical digital channels are incorporated for redundancy
         - Each channel can provide all engine and propeller functions without limitations
      c. In many aircraft, the FADEC uses power from a separate generator connected to the engine

12. Propeller AI.II.E.K1c

A. General
   i. A rotating airfoil
      a. Subject to induced drag, stalls, and other aerodynamic principles
   ii. Engine power is used to rotate the propeller
      a. Rotation generates thrust very similar to the way a wing produces lift
      b. The amount of thrust depends on the shape of the airfoil, the angle of attack of the blade, and the rpm
   iii. Prop is twisted – the blade angle changes from hub to tip
      a. The greatest angle of incidence (highest pitch) is at the hub
      b. The smallest angle of incidence (lowest pitch) is at the tip
      c. The prop is twisted to provide uniform lift from the hub to the tip
         - As the prop rotates, the tip of the blade travels faster than the hub
            a The tip travels a larger distance in the same amount of time as the hub (like overbanking tendency)
         - A prop that wasn't twisted would be inefficient
            a As airspeed increases, the portion near the hub would have a negative AOA while the tip would be stalled



   iv. Installation
      a. Mounted on a shaft, which may be an extension of the engine crankshaft
         - If it is directly connected to the crankshaft, the rpm of the propeller is the same as the crankshaft

rpm

- On some engines, the propeller is mounted on a shaft that is geared to the engine crankshaft
    - a In this case, the rpm of the propeller is different than that of the engine
    - b For example, the Diamond DA42 is geared at a ratio of 1.69:1
        1. The engine spins 1.69 rpm to every 1 prop rpm

v. Two types of propellers
   a. Fixed pitch
   b. Adjustable pitch

B. Fixed Pitch
   i. General
      a. Fixed blade angle
         - The pitch of the propeller is set by the manufacturer and cannot be changed
         - Fixed pitch propellers only achieve their best efficiency only at a given combination of airspeed and RPM
             - a The pitch setting is neither ideal for cruise or climb, and the aircraft suffers a bit in each category
      b. Used when low weight, simplicity, and low cost are needed
      c. Two types of fixed-pitch propellers
         - Climb
         - Cruise
   ii. Climb Propeller
      a. Lower pitch, and therefore less drag
         - Less drag results in higher RPM and more horsepower capability
             - a This increases performance during takeoffs and climbs
             - b This decreases performance during cruise
   iii. Cruise Propeller
      a. Higher pitch, and therefore more drag
         - More drag results in lower RPM and less horsepower capability
             - a This decreases performance during takeoff and climbs
             - b This increases performance during cruise
   iv. Control and Indications
      a. Tachometer
         - Indicator of power
             - a Calibrated in hundreds of rpm
             - b Direct indication of the engine and propeller rpm

      b. Controlling rpm
         - The rpm is regulated by the throttle which controls the fuel-air flow to the engine
             - a At a given altitude, the higher the tachometer reading, the higher the power output of the engine
             - b As altitude increases, the tachometer may not show correct engine power output
                 1. Power output depends on air density
                     a. Air density decreases as altitude increases
                     b. A decrease in air density decreases power output of the engine
                     c. As altitude changes, the position of the throttle must be changed to maintain the same rpm (throttle must be increased to maintain the same rpm at a higher altitude)

C. Adjustable Pitch (Constant-speed propeller)

i. General
   a. A constant-speed propeller is a controllable pitch propeller whose pitch is automatically varied in flight by a governor
      - Governor maintains constant rpm despite varying air loads on the propeller
   b. More efficient than other propellers because it allows selection of the most efficient engine rpm for the given conditions
      - Pitch can be adjusted for climb, cruise, and in between
ii. How it Works
   a. Once a specific rpm is selected, the governor automatically adjusts the propeller blade to maintain the selected rpm
      - For example, after setting the rpm, an increase in airspeed or decrease in propeller load causes the governor to increase the propeller blade angle to maintain the selected rpm
         a In this case, the propeller would normally accelerate, but the governor increases the blade angle (bigger bites of air) to maintain the desired rpm
      - A reduction in airspeed or increase in load causes the propeller blade to decrease
         a This would slow down a fixed pitch propeller, but the governor decreases the blade angle (smaller bites of air) to maintain the same rpm
   b. As long as the propeller blade angle is within its rpm range, a constant rpm is maintained
      - If the propeller blade reaches a pitch stop (i.e. the blade cannot rotate any farther higher or lower), the engine rpm will then increase or decrease (like a fixed pitch propeller)
         a For example, if airspeed decreases enough to rotate the propeller blades until they contact the low pitch stop, any further decrease in airspeed will cause the engine rpm to decrease. The same concept applies to the high pitch stop, but will result in an rpm increase
iii. Controls and Indications
   a. 2 controls - Throttle and Propeller control
      - Throttle controls power output
      - Propeller control regulates propeller rpm through the governor
         a Rpm is shown on the tachometer
   b. Manifold Pressure Gauge

      - Power output is controlled by the throttle and indicated on the manifold pressure gauge
         a Gauge measures the absolute pressure of the fuel-air mixture in the intake manifold
      - At a constant rpm and altitude, the amount of power produced is directly related to the fuel-air mixture being delivered to the combustion chamber
         a As the throttle is increased, more fuel and air flows to the engine and manifold pressure increases. Pressure decreases if power is reduced
      - For any given rpm there is a manifold pressure that should not be exceeded
         a If manifold pressure is excessive for a given rpm, the pressure in the cylinders could be exceeded, placing undue stress on the cylinders
            1. If repeated too often, the stress can weaken the cylinder components and lead to engine failure
      - Always consult the manufacturer’s power/rpm settings in the POH
   c. Adjusting power and rpm
      - Decreasing power

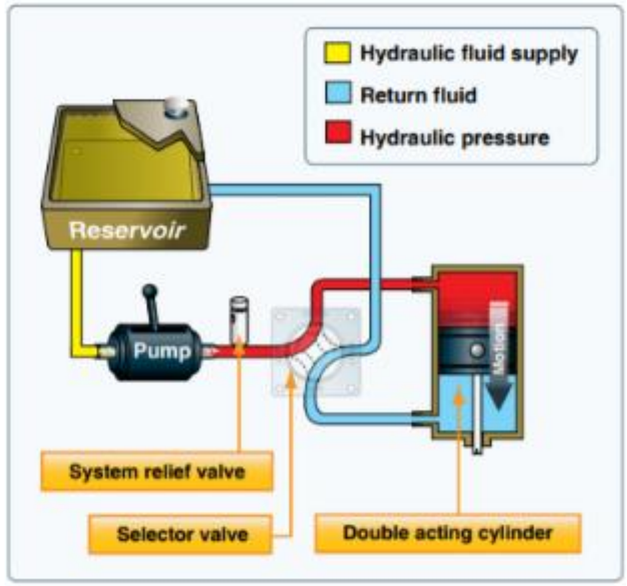
- a. Reduce manifold pressure, then rpm (**L**ower power = **L**eft to right – throttle, rpm)
- b. If rpm is reduced before manifold pressure, manifold pressure automatically increases, potentially exceeding engine tolerances
- Increasing power
  - a. Increase rpm, then manifold pressure (**R**aise power = **R**ight to left – rpm, throttle)

13. Landing Gear and Brakes (Hydraulics) AI.II.E.K1d, AI.II.E.K1e

A. Landing Gear
  i. General
    a. Types of Landing Gear
      - Most common is wheels, but airplanes can also be equipped with floats for water, or skis for landing on snow
    b. The landing gear on small aircraft consist of three wheels:
      - Two main wheels, one on either side of the fuselage
      - A third wheel positioned at the front or the rear of the airplane
        - a. Conventional (tailwheel)
          1. When the third wheel is positioned at the rear
        - b. Tricycle
          1. When the third wheel is positioned at the nose
    c. Fixed and Retractable Landing Gear
      - Fixed
        - a. Always remains extended
        - b. Advantage of simplicity and low maintenance
      - Retractable
        - a. Designed to streamline the airplane by allowing the landing gear to be stowed inside the structure during cruise flight
  ii. Tricycle Landing Gear
    a. Three advantages:
      - Allows more forceful brake application during landings without causing the aircraft to nose over
      - Permits better forward visibility during takeoff, landing, and taxiing
      - Tends to prevent ground looping by providing more directional stability during ground operation since the aircraft's center of gravity is forward of the main wheels
        - a. The forward center of gravity keeps the airplane moving forward in a straight line rather than ground looping
    b. Nosewheel
      - The nosewheel is either steerable or castering
        - a. Steerable nosewheels are linked to the rudders by cables or rods
        - b. Castering nosewheels are free to swivel
      - In either case, the aircraft is steered using rudder pedals
        - a. Castering nosewheels may require the combination of rudder pedals and brakes
  iii. Tailwheel Landing Gear
    a. Two main wheels attached to the airframe ahead of the center of gravity that support most of the weight of the structure
      - A tailwheel at the very back of the fuselage provides a third point of support
    b. Advantages of the tailwheel:
      - Adequate ground clearance for a larger propeller
      - More desirable for operations on unimproved fields
    c. Disadvantages of the tailwheel:

- With the CG located behind the main gear, directional control is more difficult while on the ground
  - a For example, if the pilot allows the airplane to swerve while rolling on the ground at a low speed, there may not be sufficient rudder control and the center of gravity will attempt to get ahead of the main gear, which may cause the airplane to ground loop
- Diminished forward visibility when the tailwheel is on or near the ground

B. Hydraulics



i. Standard Hydraulic Components:
a. Reservoir
b. Pump
c. Filter
d. Selector Valve
e. Relief Valve
f. Actuator or servo

ii. Operation
a. Hydraulic fluid is pumped from the reservoir through a filter and then to an actuator or servo
- Servo – cylinder with a piston inside that turns fluid power into work and creates the power needed to move an aircraft system or flight control
  - a Servos can be single-acting or double-acting (fluid can be applied to one or both sides of the servo)

b. The selector valve allows the fluid direction to be controlled
- For example, extension and retraction of the landing gear. The fluid has to work in two different directions and the selector valve allows that based on the gear selector position in the flight deck (extend or retract)

c. The relief valve provides an outlet for the system in the event of excessive fluid pressure

C. Brakes
i. Located on the main wheels
ii. Applied by either a hand control or foot pedal (most common)
a. Foot pedals operate independently and allow for differential braking
b. Differential braking can supplement steering

14. Fuel Systems AI.II.E.K1e

A. General
i. Designed to provide uninterrupted, clean fuel from the tanks to the engine
ii. Fuel must be available under all conditions (engine power, altitude, attitude, and approved flight maneuvers)
iii. Two common types of fuel systems in general aviation aircraft
a. Gravity Feed
- Uses gravity to transfer fuel from the tank(s) to the engine(s)
  - a Ex: On high-wing airplanes the fuel tanks are installed in the wings
    1. Fuel is above the carburetor and gravity fed to it

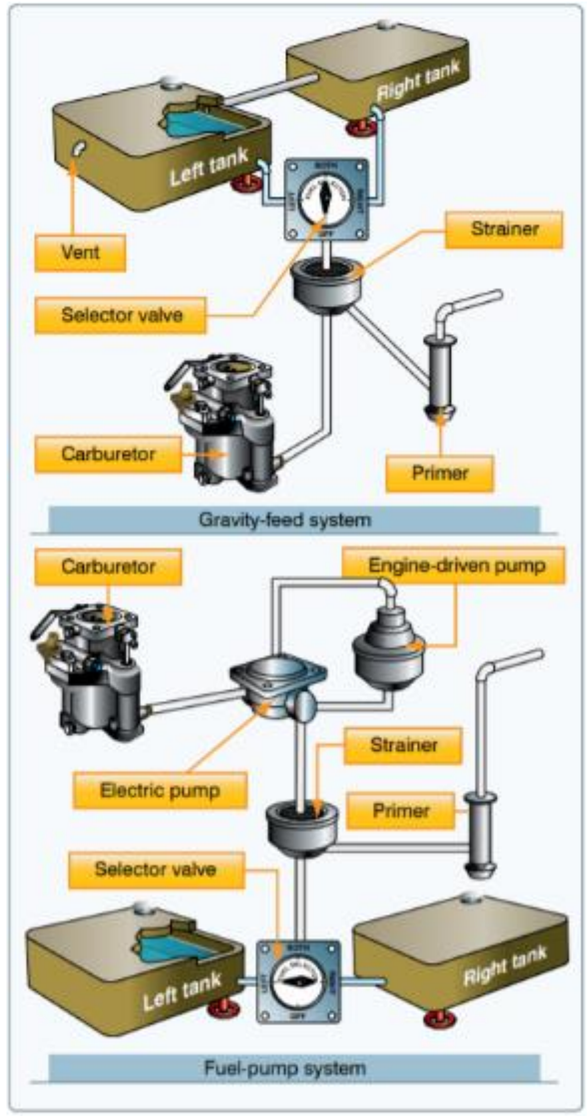
b. Fuel-Pump System
- If gravity cannot transfer the fuel (low-wing airplanes), fuel pumps are used
- Two fuel pumps per engine
  - a Engine driven pump

1. This is the main/primary fuel pump
2. Operates whenever the engine is operating

b Electrically-driven auxiliary pump

1. Used for engine start, and as a backup to the main pump

B. Fuel Tank and Strainer
   i. Fuel Tank(s)
      a. Normally located in the wings of an airplane
      b. Vented to the outside to maintain atmospheric pressure in the tank
      c. Include an overflow drain
         - Allows fuel to expand with increased temperature and not damage the tank



   ii. Strainer
      a. After leaving the fuel tank, fuel passes through a strainer that removes any moisture (water) and other sediments in the system
         - Contaminants like these are heavier than aviation fuel and settle in a sump (low point in a fuel system and/or fuel tank) at the bottom of the strainer
      b. The strainer should be drained before each flight
         - Use the drain tool to check for the proper type of fuel, as well as water and other contaminants in the fuel
      c. Water is the principal fuel contaminant
         - Water can be hazardous because in cold weather it can freeze and block fuel lines
            a In warm weather it can flow into the carburetor and stop the engine
         - If water is present in the sump, it is likely that there is more water in the fuel tanks and they should be drained until there is no evidence of water
         - Water droplets can be identified by a cloudy appearance of the fuel, or by the clear separation of water from the colored fuel
      d. To prevent condensation, fuel tanks should be filled after each flight or after the last flight of the day

C. Fuel Selectors
   i. Allows selection of fuel from various tanks, if installed
      a. Common settings include, Left, Right, Both, Off
      b. Selecting Left or Right allows fuel to feed only from the respective tank, while Both feeds fuel from both tanks
         - Left and Right may be used to balance the fuel remaining in each wing tank, or to isolate one tank
   ii. Always monitor the fuel consumption and quantities in each tank
      a. Many aircraft do not have a Both selection, and therefore the selector must be swapped between Left and Right to maintain a balance

- Disregarding the fuel can lead to running an individual tank dry, as well as unbalanced fuel loads
    - a Running a tank dry may allow air to enter the fuel system and cause vapor lock, which makes it difficult to restart the engine
    - b On fuel-injected engines, the fuel becomes so hot it vaporizes in the fuel line, not allowing fuel to reach the cylinders

D. Fuel Primer
- i. Draws fuel from the tanks to vaporize fuel directly into the cylinders prior to starting the engine
    - a. Used in both gravity-feed, and fuel-pump systems
- ii. During cold weather, when engines are difficult to start, the fuel primer helps because there is not enough heat available to vaporize the fuel in the carburetor
- iii. The primer should be locked in place when not in use
    - a. An unlocked primer can rattle lose out of flight and cause an excessively rich mixture

E. Fuel Gauges
- i. Fuel Quantity Gauge(s)
    - a. Indicate the amount of fuel in each tank to the pilot
    - b. Aircraft certification rules only require accuracy in fuel gauges when they read “empty”
        - Any reading other than empty should be verified
        - Always visually check the fuel level in each tank during the preflight and compare it to the tank quantity indications
- ii. Fuel Pressure Gauge
    - a. If a fuel pump is installed, a fuel pressure gauge is included with it
    - b. Indicates the pressure in the fuel lines
        - The POH can provide more detailed information in regard to the indications

15. Electrical Systems AI.II.E.K1f

A. General
- i. Most aircraft are equipped with either a 14 or 28-volt direct current (DC) electrical system
- ii. A basic electrical system consists of the following:
    - a. Alternator/generator
    - b. Battery
    - c. Master/battery switch
    - d. Alternator/generator switch
    - e. Bus bar, fuses, and/or circuit breakers
    - f. Voltage regulator
    - g. Ammeter/loadmeter
    - h. Electrical wiring

B. Power Generation
- i. Engine-driven alternators or generators supply electric current to the electrical system and also maintain a sufficient charge in the battery
- ii. Some DC generators do not produce sufficient power to operate the entire electrical system at low engine rpm
    - a. In this case, the excess electrical needs will be drawn from the battery, which can quickly be depleted
- iii. Alternators have several advantages over generators
    - a. Alternators produce sufficient current to operate the entire electrical system, even at low engine speeds, by producing alternating current (AC), which is converted to DC

b. The electrical output of alternators is more constant through a wide range of engine speeds

iv. Voltage Regulator (contained in most systems)

a. Controls the rate of charge to the battery by stabilizing generator/alternator output

b. The generator/alternator voltage should be higher than the battery voltage

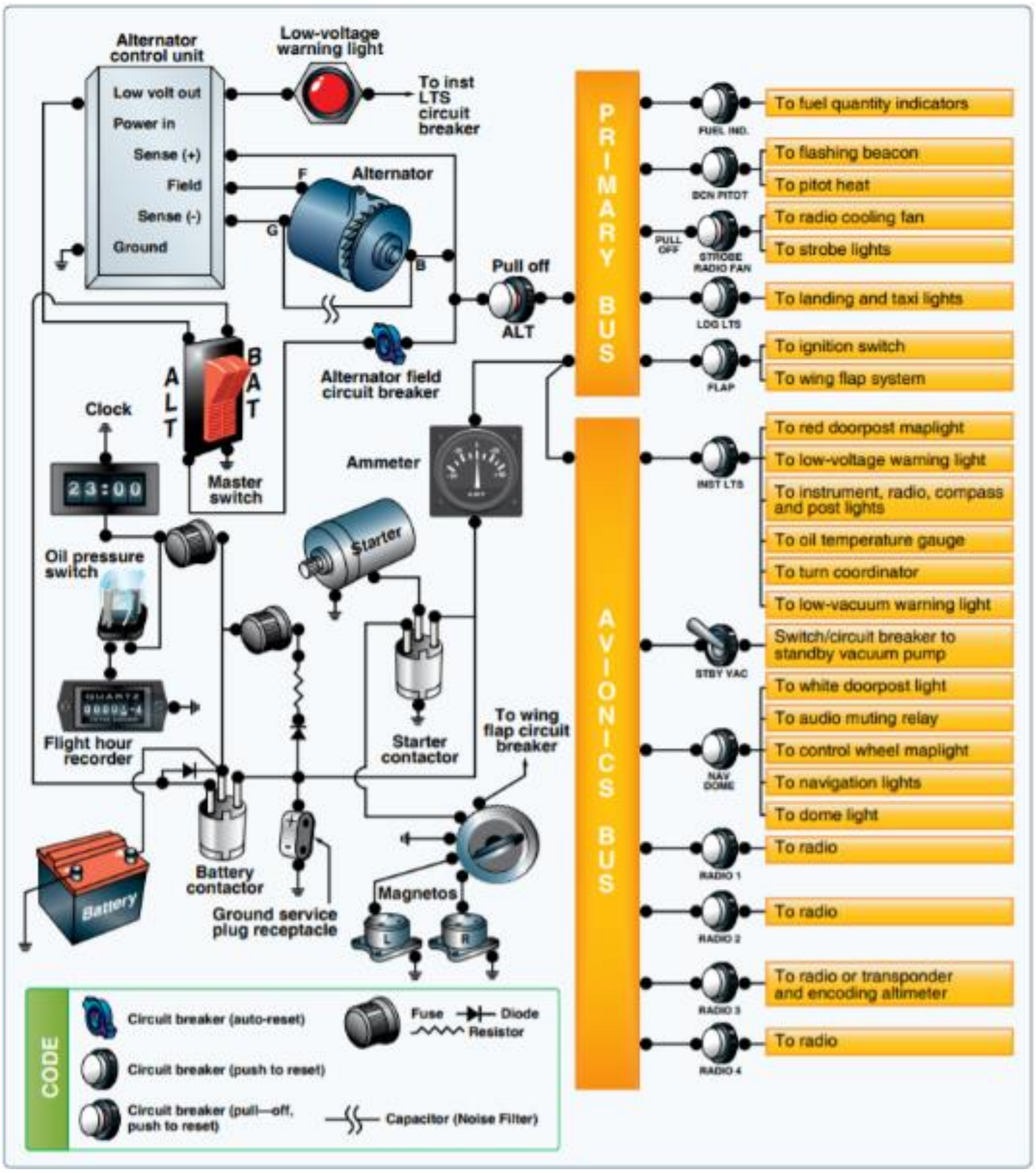
- Ex: a 12-volt battery would be fed by a generator/alternator system of approximately 14 volts
- The difference in voltage keeps the battery charged

C. Power Storage

i. Power is stored in batteries, primarily the main battery

a. Used as a source of electrical power for starting the engine, and a limited supply of electrical power for use in the event the alternator or generator fails

D. Power Distribution



i. A bus bar is used as a terminal in the aircraft electrical system to connect the main electrical system to the equipment using electricity as a source of power

a. Distributes the power from the alternator/generator/battery to the components using the power

E. Protection
   i. Fuses or circuit breakers are used to protect the circuits and equipment from electrical overload
      a. Spare fuses should be carried
      b. Circuit breakers have the same function as a fuse but can be manually reset, rather than replaced, if an overload occurs
F. Indications
   i. Ammeter
      a. Monitors the performance of the aircraft electrical system
      b. Shows if the alternator/generator is producing an adequate supply of electrical power and indicates if the battery is receiving an electrical charge
      c. Ammeter Indications
         - Designed with the zero point in the center of the face, a negative indication on the left, and a positive indication on the right
            a When the pointer is on the plus side, it shows the charging rate of the battery
            b When the pointer is on the minus side, it shows the discharge rate of the battery
               1. More current is being drawn from the battery than is being replaced

         - A full scale minus deflection indicates a malfunction of the alternator/generator
         - A full scale plus deflection indicates a malfunction of the regulator
      d. Not all aircraft are equipped with an ammeter, some only show a warning light that, when lighted, indicates a discharge in the system as a generator/alternator malfunction
   ii. Loadmeter
      a. Shows the load being placed on the alternator/generator
         - Reflects the total percentage of the load placed on the generating capacity of the electrical system by the electrical accessories and battery
         - When all electrical components are turned off, it reflects on the amount of charging current demanded by the battery

16. Avionics AI.II.E.K1g

A. Avionics can vary greatly, especially with the advent and large-scale acceptance of glass displays
   i. Electronic instrument displays, GPS's, autopilots, radios, traditional instruments (vacuum, gyro, etc.)
      a. G1000, Avidyne, etc.
   ii. Be familiar with the avionics displays and instruments associated with your aircraft and their use
      a. Manage automation
      b. Do not become distracted with the seemingly unlimited functionality of glass flight decks
      c. Reference the avionics user manual(s)
B. Autopilot
   i. Automatic flight control system that keeps an aircraft in level flight or on a set course
      a. Can be directed by the pilot or coupled to a radio navigation signal
   ii. Reduces physical and mental demands on a pilot and increases safety
   iii. Autopilots vary greatly in complexity
      a. The simplest systems use gyroscopic attitude indicators and magnetic compasses to control servos connected to the flight control system
      b. The number and location of the servos depends on the complexity of the system
         - For example, a single-axis autopilot controls the aircraft about the longitudinal axis and a servo

actuates the ailerons

- A three-axis autopilot controls the aircraft about the longitudinal, lateral, and vertical axes
  - a Three different servos actuate ailerons, elevator, and rudder
- More advanced systems often include a vertical speed and/or indicated airspeed hold mode
- Advanced autopilot systems are coupled to navigational aids through a flight director
  - a These autopilots work with inertial navigation systems, GPS, and flight computers to control the aircraft

iv. Most autopilot systems also incorporate a disconnect safety feature to disengage the system automatically or manually

a. This allows the pilot to override an autopilot malfunction

C. Because avionics systems differ widely in their operation, refer to the manufacturer's operating instructions

17. Flight Instruments AI.II.E.K1h

A. Pitot-Static Flight Instruments

i. Combined system that utilizes the static air pressure (static ports) and dynamic pressure (pitot tube) due to the motion of the aircraft through the air

a. Utilized for the operation of the airspeed indicator, altimeter, and vertical speed indicator

ii. How it Works

a. Flight instruments depend on accurate sampling of the ambient atmospheric pressure

- This is used to determine the height and speed of movement of the aircraft through the air

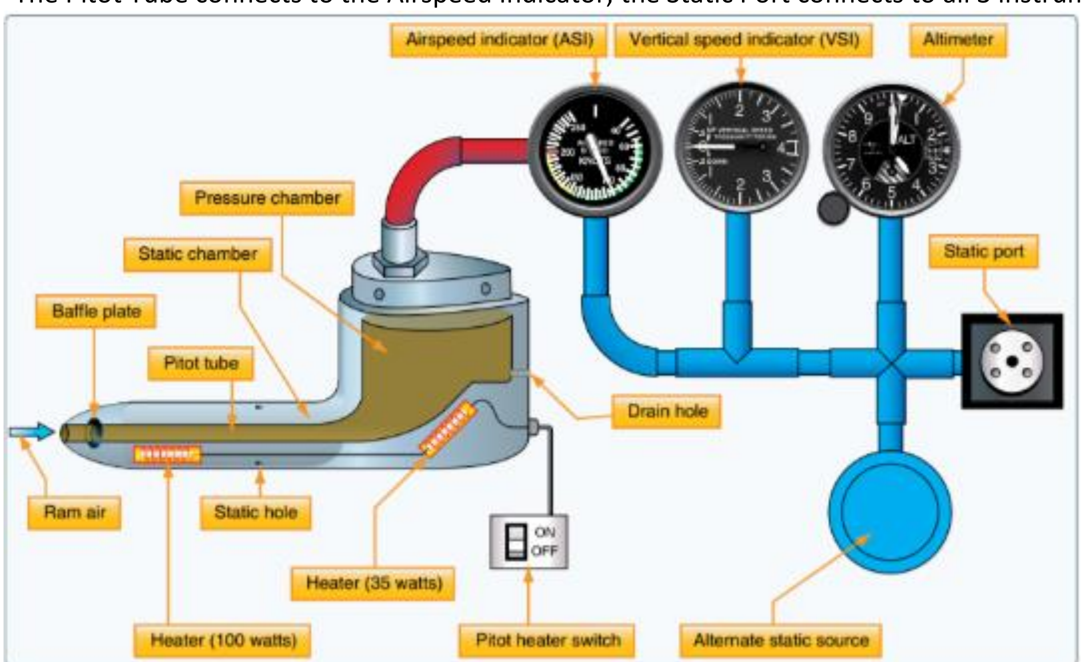
b. Static Pressure (still air pressure) is measured at a flush port where air is not disturbed

- Pressure of the air that is still or not moving, measured perpendicular to the aircraft surface

c. Pitot Pressure (impact air pressure) is measured through a tube pointed into the relative wind

- Ram air pressure used to measure airspeed

d. The Pitot Tube connects to the Airspeed Indicator; the Static Port connects to all 3 instruments



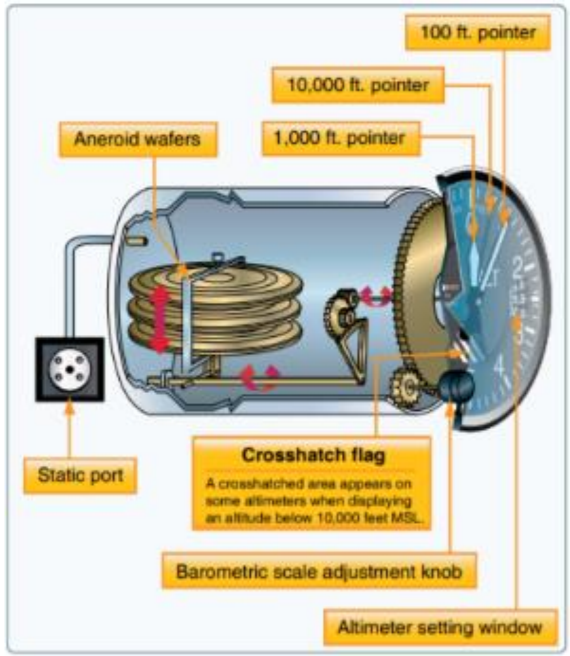
iii. Sensitive Altimeter

a. An aneroid barometer that measures the absolute pressure of the ambient air and displays it as feet above a selected pressure level

b. Principle of Operation

- The sensitive element is a stack of evacuated, corrugated bronze aneroid capsules

- a Air pressure tries to compress them, while natural springiness tries to expand them
- b This results in their thickness changing as their air pressure changes
  1. The change in thickness moves the gears/linkages to change the altitude displayed
- Contains an adjustable barometric scale (visible in the Kollsman window)
  - a This allows you to set the reference pressure from which the altitude is measured
  - b Rotating the knob changes the barometric scale: 1" Hg is equal to 1,000'
    1. Standard pressure lapse rate below 5,000'
  - c Pressure altitude is when the Kollsman window is set to 29.92" Hg
  - d When you want to display indicated altitude, adjust to the local altimeter setting
    1. This will indicate the height above the existing sea level pressure

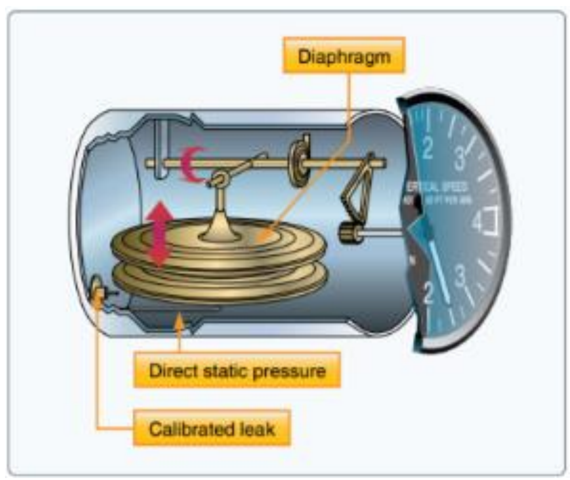


c. Errors (Mechanical and Inherent)
- Nonstandard Temperature
  - a When in warmer than standard air, air is less dense and pressure levels are farther apart
    1. At 5,000' indicated, true altitude is higher than it would be if the air were cooler
       a. The pressure level for that alt is higher than it would be at standard temp
  - b If air is colder than standard, it is denser, and pressure levels are closer together
    1. At 5,000' indicated, true altitude is lower than it would be if the air were warmer
       a. The pressure level for that alt is higher than it would be at standard temp
- Nonstandard Pressure
  - a High pressure to Low pressure
    1. As the pressure decreases, the altimeter reads it as though the airplane is climbing
       a. The altimeter increases although the airplane is at the same altitude
          i. To compensate for this the pilot will descend, therefore lowering true altitude and putting the aircraft in a potentially dangerous position (lower than the altimeter indicates)
  - b Opposite applies from low to high pressure
- REMEMBER: From hot to cold, or from high to low, look out below!

iv. Vertical Speed Indicator

a. A rate-of-pressure change instrument giving an indication of deviation from a constant pressure level

b. Principle of Operation
- Inside the instrument case is an aneroid
  - a Both the aneroid and the inside of the case are vented to the static system
    1. But the case is vented through a calibrated orifice that causes the pressure inside to change more slowly than that inside the aneroid



- As the aircraft ascends, the static pressure becomes lower (Descent is the opposite)
  - a The pressure inside the case compresses the aneroid, moving the pointer upward
- When the aircraft levels off, the pressure no longer changes
  - a The pressure inside the case becomes the same as that inside the aneroid

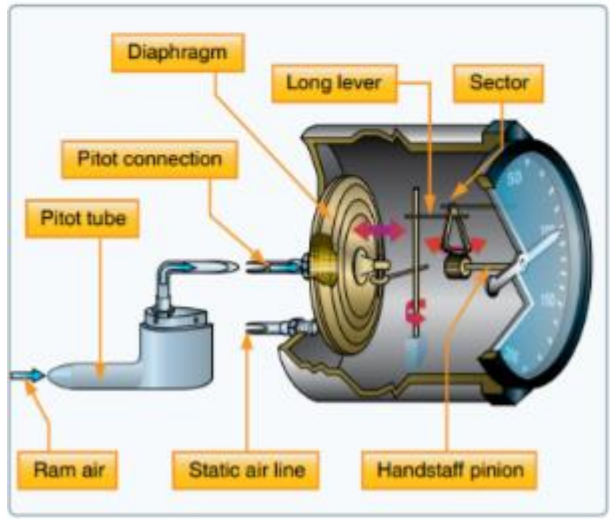
v. Airspeed Indicator

a. A differential pressure gauge measuring the dynamic pressure of the air the aircraft is in

- Dynamic Pressure: the difference in ambient static air pressure and the total, or ram, pressure caused by the motion of the aircraft through the air

b. Principle of Operation

- Consists of a thin, corrugated phosphor bronze aneroid, or diaphragm, receiving its pressure from the pitot tube
- The instrument is sealed and connected to the static port(s)
- As pitot pressure increases/ static decreases, the diaphragm expands and vice versa
  - a A rocking shaft and set of gears drives the airspeed needle



vi. Electronic Flight Display

a. General

- Digital displays have become increasingly popular over the years, and although they display the same, and more, information, the methods have changed
- Pitot-static information now comes from an Air Data Computer or ADC

b. Air Data Computer (ADC)

- EFDs utilize the same instrument inputs as traditional gauges (pitot/static inputs), however the processing is different
- The pitot static inputs are received by an ADC
  - a The ADC computes the difference between the total pressure and the static pressure and generates the information necessary to display the airspeed on the PFD
  - b Altitude information is derived from the static port just as an analogue system does; however, the static pressure does not enter a diaphragm
    1. The ADC computes the received barometric pressure and sends a digital signal to the PFD (primary flight display) to display the proper altitude

B. Gyroscopic System (Attitude Indicator, Heading Indicator, Turn Coordinator)

i. How it Works

a. The 2 characteristics of gyroscopes: Rigidity and Precession

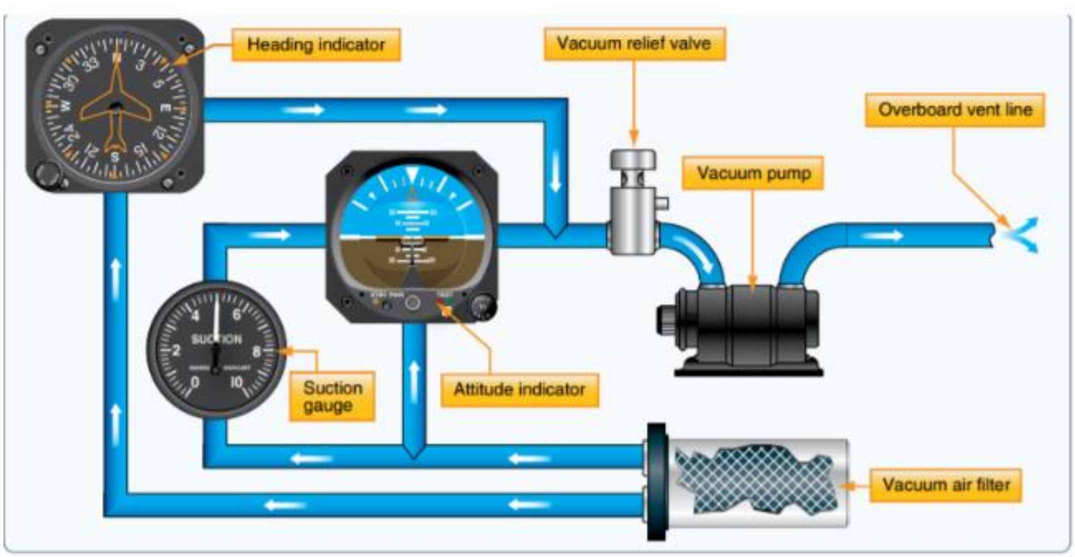
- Rigidity: Characteristic that prevents its axis or rotation tilting as the Earth rotates
- Precession: Characteristic that causes an applied force to be felt 90° from that point in the direction of rotation

b. The instruments contain a gyro (small wheel with its weight concentrated around its periphery)

- When spun at a high speed, the wheel becomes rigid, resisting any attempt to tilt or turn in any direction other than around its spin axis
  - a Attitude/Heading instruments operate on the principle of rigidity
    1. The gyro remains *rigid* in its case and the aircraft rotates about it

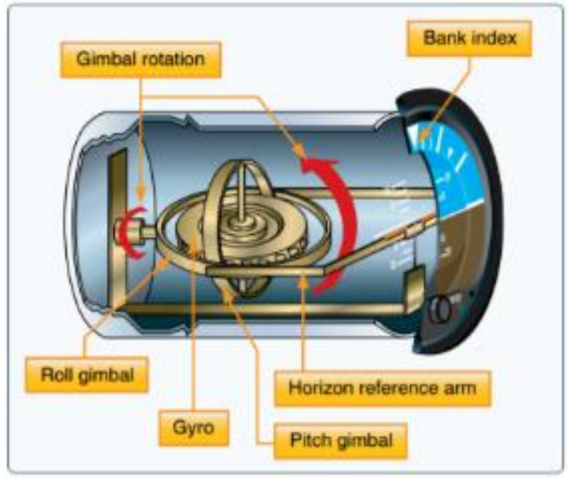
- Rate indicators (turn indicators/turn coordinators) operate on the principle of precession
    - a The gyro precesses (or rolls over) proportionate to the rate the aircraft rotates about one or more of its axes

c. Power Sources
- Electrical Systems
- Pneumatic (vacuum) Systems
    - a Driven by a jet of air impinging on buckets cut into the periphery of the wheel
- Venturi Tube Systems
    - a Air flows through venturi tubes mounted on the outside of the aircraft
        1. The constricted part of the tube (low pressure) is connected to the instruments
            a. This creates a suction
- Wet-Type Vacuum Systems
    - a Steel vane air pumps are used to evacuate the instrument cases
    - b The vanes in the pumps are lubricated with oil which is discharged with the air
    - c Excess air can be used inflate deicer boots
- Dry-Air Pump Systems
    - a At high altitudes, more air is needed in the instruments as the air is less dense
        1. Air pumps that do not mix oil with the discharge air are used in high flying
    - b Vanes are made of a special formulation of carbon which do not need lubricating
- Pressure Systems
    - a 2 dry air pumps are used with filters to filter anything that could damage the fragile carbon vanes in the pump
    - b The discharge air from the pump flows through a regulator, where excess air is bled off to maintain the pressure in the system at the desired level
    - c The regulated air then flows through inline filters to remove any contamination that could have been picked up from the pump, and from there into a manifold check valve
    - d If either engine becomes inoperative, or if either pump fails, the check valve will isolate the inoperative system and the instruments will be driven by air from the other system
    - e After passing through the instruments/driving the gyros, air is exhausted from the case
    - f The gyro pressure gauge measures the pressure drop across the instruments



ii. Attitude Indicator

a. Principle of Operation
- Its operating mechanism is a small brass wheel with a vertical spin axis
  - a It is spun by either a stream of air on buckets cut into its periphery or an electric motor
- Mounted in a double gimbal which allows the aircraft to pitch and roll about the gyro
  - a A type of mount in which the axes of the two gimbals are at right angles to the spin of the axis of the gyro allowing free motion in two planes around the gyro
- A horizon disk is attached to the gimbals so it remains in the same plane as the gyro
  - a The airplane pitches and rolls around the horizon disk



- A small aircraft is put in the instrument case so it appears to be flying relative to the horizon
  - a The aircraft can be raised or lowered
- To function properly, the gyro must remain vertically upright while the aircraft pitches/rolls
  - a The bearings have a minimum of friction, but even the small amount causes precession
    1. To minimize tilting, an erection mechanism applies a force any time the gyro tilts to return it to the upright position

b. Errors
- Free from most errors, but…
  - a There may be a slight nose-up indication during a rapid acceleration and vice versa
  - b There is also the possibility of a small bank angle and pitch error after a 180° turn

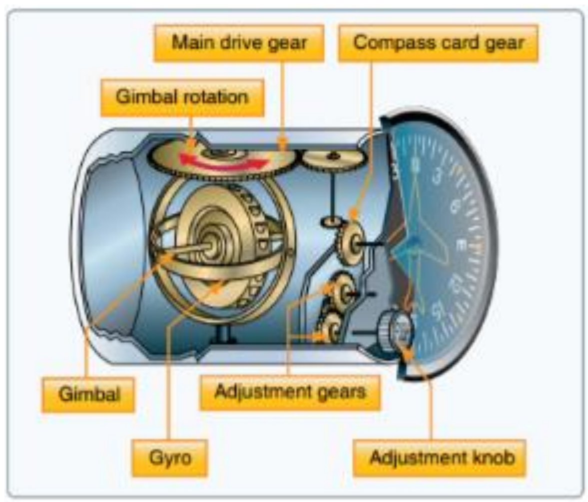
iii. Heading Indicator

a. The gyro is mounted in a double gimbal axis in such a way that its spin axis is horizontal
- Senses rotation about the vertical axis of the airplane

b. Must be set to the appropriate heading by referring to a magnetic compass
- Rigidity causes them to maintain this heading indication

c. Air driven: air flows into the case, blowing against buckets in the periphery of the wheel

d. The instrument should be checked every 15 minutes to ensure it matches the magnetic compass



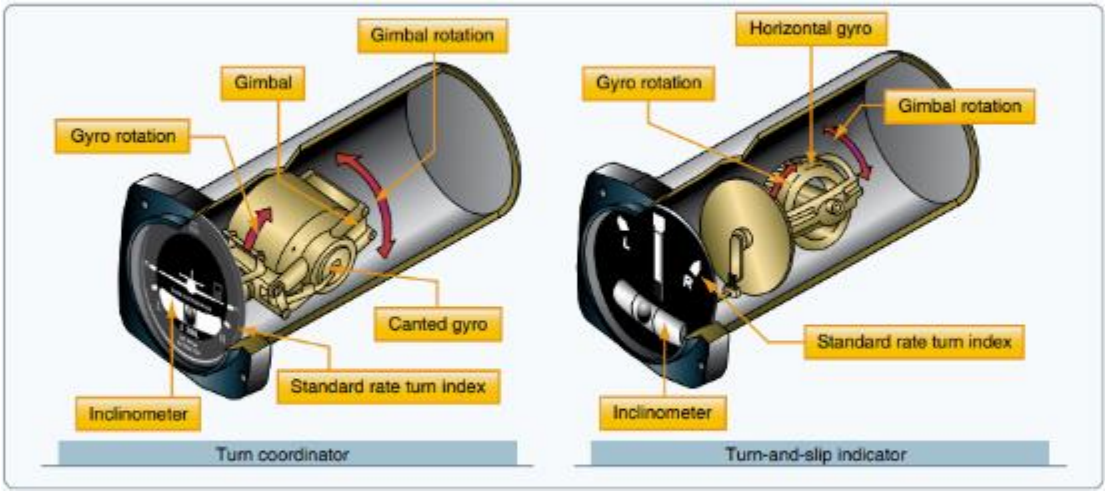
iv. Turn Indicators

a. General
- Two types of turn indicators: Turn-and-slip, and Turn coordinators
- Both instruments indicate turn direction and quality of turn (coordination)
  - a Turn-and-slip shows direction and rate of turn
  - b Turn coordinator (canted gyro) shows direction and rate of turn and rate of roll
- Provides a backup source of bank information if the attitude indicator fails

b. Operation
- Gyro is powered by air or an electric motor

- Small gyro mounted in a single gimbal
  - a Gyro rotates in the vertical axis, corresponding to the aircraft's longitudinal axis
- Yawing produces a force in the horizontal plane
  - a Precession causes any yawing forces to tilt the gyro to the left or right
  - b A spring works to maintain the center position
  - c Spring also makes the indicator incapable of tumbling off its rotational axis

c. Turn-and-Slip Indicator
- Direction and rate of turn is displayed by the turn needle as yawing forces tilt the gyro



d. Turn Coordinator (more common in GA aircraft)
- Very similar to the turn-and-slip but the gimbal is canted so the gyro can sense both rate of roll as well as rate of turn
  - a When rolling in/out of a turn, the miniature aircraft banks in the direction of the turn
  - b A rapid roll rate causes the mini aircraft to bank more steeply than a slow roll rate
  - c Only indicates rate and direction of turn; does not indicate angle of bank
- Used to establish and maintain a standard-rate turn (3° per second)
  - a Align the wing of the mini aircraft with the turn index

v. Electronic Flight Display

a. In the electronic flight display, the gyroscopic instruments have been replaced by the AHRS (attitude and heading reference system)

b. AHRS
- Electronic flight displays have replaced free-spinning gyros with sold-state laser systems that are capable of flight at any attitude without tumbling
- The AHRS sends attitude information to the PFD to generate the pitch and bank information of the attitude indicator
- The heading information is derived from a magnetometer that senses the earth's lines of magnetic flux
- All the information is processed and then sent to the PFD to be displayed

18. Environmental Systems AI.II.E.K1i

A. Heading

i. There are many different types of aircraft heating systems depending on the type of aircraft

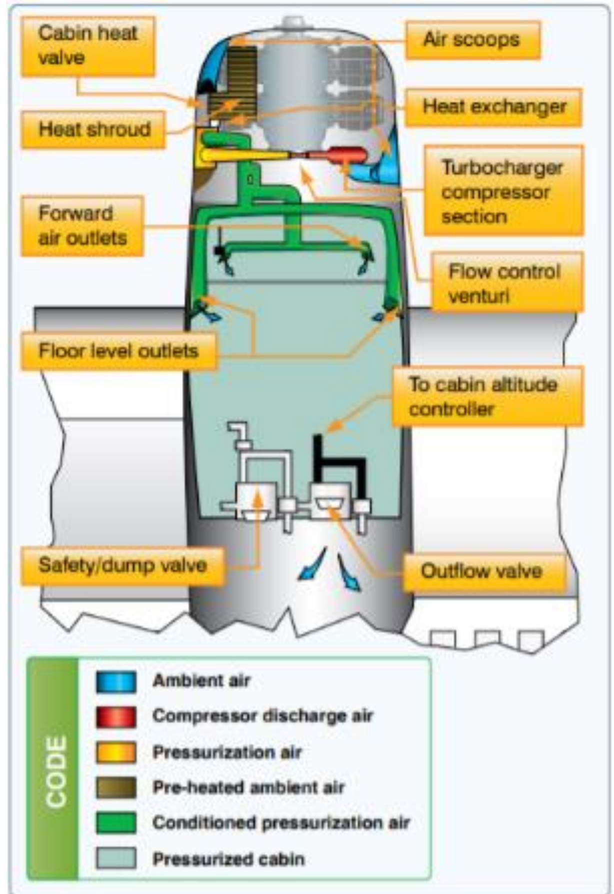
a. Fuel Fired Heaters

b. Exhaust Heating Systems

c. Combustion Heating Systems

        d. Bleed Air Heating Systems
    ii. Exhaust Heating Systems
        a. The simplest type of aircraft heating system and are used on most light aircraft
        b. The engine exhaust system is used as a heat source for the cabin and carburetor (if carbureted)
        c. Operation
            - Outside air is drawn into the air inlet and is ducted through a shroud around the muffler
                a The muffler is heated by the exiting exhaust gases, and in turn heats the air around the muffler
            - The heated air is ducted to the cabin for heat and defrost
        d. Exhaust gases contain large amounts of carbon monoxide, which is odorless and colorless, and deadly
            - To ensure exhaust gases are properly expelled, and not brought into the cabin through the heating system, the exhaust must be in good condition and free of cracks
    iii. Fuel Fired Heaters
        a. A small mounted or portable space-heating device
        b. Operation
            - Fuel is brough to the heater's combustion chamber by using piping from a fuel tank, or taps in the aircraft's fuel system
            - A fan blows air into the combustion chamber, and a spark plug, or ignition device ignites the fuel-air mixture
            - Outside the combustion chamber, a second, larger diameter tube conducts air around the combustion tube's outer surface, and a second fan blows the warmed air into tubing which takes it to the aircraft cabin
        c. Because gasoline heaters are required to be vented, special care must be made to ensure the vents do not leak into the interior of the aircraft
    iv. Combustion Heater Systems
        a. Often used to heat larger, more expensive aircraft
        b. Operation
            - Burns the aircraft's fuel in a combustion chamber or tube to develop required heat
            - Air flowing around the tube is heated and ducted to the cabin
            - The byproduct, carbon monoxide exits through the heater's exhaust pipe
            - The system is activated by the thermostat
                a The thermostat turns on the fuel solenoid allowing fuel into the burner chamber where it is burned
                b As the thermostat reaches its preset/desired temperature, it turns off fuel into the burner chamber, and the cycle continues
        c. Very Safe
            - Overheat switch – shuts off fuel in the case of a malfunction
            - Unlikely for carbon monoxide poisoning to occur
                a Low pressure in the combustion tube, high pressure outside the combustion tube
                b If there were a leak, the high-pressure air outside the combustion tube would travel into the chamber and exit the exhaust
    v. Bleed Air Heating Systems
        a. Used on turbine-engine aircraft
        b. Operation
            - Extremely hot, compressed bleed air is ducted into a chamber where it is mixed with ambient or re-circulated air to cool it to a useable temperature, and then is ducted into the cabin
        c. Safety Features
            - Temperature sensors that prevent excessive heat from entering the cabin

- Check valves to prevent a loss of compressor bleed air when starting the engine and when full power is required
- Engine sensors to eliminate the bleed system if the engine becomes inoperative



B. Pressurization
  i. General
    a. Aircraft are flown at high altitudes for two reasons:
      - More efficient - Less fuel consumed for a given airspeed
      - Bad weather and turbulence may be avoided by flying above the storms
    b. To fly at high altitudes, the aircraft must be pressurized
      - Pressurization is necessary to protect occupants against hypoxia and the effects of low atmospheric pressures on the body at high altitudes
  ii. How it Works
    a. The cabin, flight and baggage compartments are incorporated into a sealed unit capable of containing air under a higher pressure than the outside atmospheric pressure (Differential Pressure)
      - Differential Pressure – the difference in pressure between the pressure acting on one side of a wall and the pressure acting on the other side of the wall (the difference between the cabin pressure and atmospheric pressure)
    b. Atmospheric air is compressed. Different aircraft systems, compress the air in in different ways:
      - Turbine powered aircraft – bleed air from the engine compressor section is used to pressurize the cabin
      - Older model turbine-powered aircraft – superchargers can be used to pump air into the sealed fuselage
      - Piston-powered aircraft – Often use air supplied from each engine turbocharger through a sonic venturi (flow limiter)
    c. The compressed air is conditioned and sent into the cabin
    d. Air is released from the fuselage through a device called an outflow valve
      - By regulating the amount of air exiting the fuselage, the outflow valve:
        a Allows for a constant inflow of air into the pressurized fuselage, and
        b Maintains the proper differential pressure
      - A typical cabin pressure altitude is 8,000’ at the maximum designed cruising altitude of the airplane
  iii. Cabin Pressure Control System
    a. Provides cabin pressure regulation, pressure relief, vacuum relief, the means for selecting the desired cabin altitude, and the means to dump the cabin pressure
      - A cabin pressure regulator, an outflow valve, and a safety valve are used to accomplish these functions
    b. Cabin Pressure Regulator – controls cabin pressure, and limits cabin pressure to a preset differential

value
- Differential control is used to prevent the maximum differential pressure, for which the fuselage was designed, from being exceeded
- If we reach the maximum differential pressure, an increase in altitude outside will result in an increase in cabin altitude

c. Outflow Valve
- Air is released from the fuselage by the outflow valve
- By regulating the air exit, the outflow valve allows for a constant inflow of air into the pressurized area and the ability to maintain a specific differential pressure

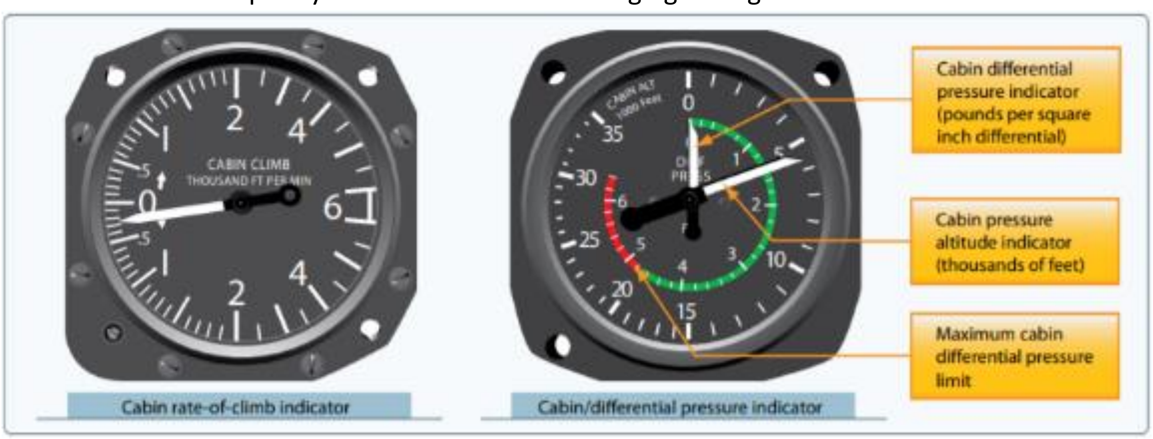
d. Cabin Air Pressure Safety Valve
- Combination of a pressure relief, vacuum relief, and dump valve
- The pressure relief valve prevents cabin pressure from exceeding a predetermined differential pressure above ambient pressure
- The vacuum relief valve prevents ambient pressure from exceeding cabin pressure by allowing external air to enter the cabin if ambient pressure exceeds cabin pressure
- The dump valve dumps the cabin air into the atmosphere
    a The cabin altitude will become equal to the atmospheric altitude
    b Controlled by a switch in the flight deck (used for emergency situations)

iv. Instruments

a. Cabin differential pressure gauge
- Indicates the difference between inside and outside pressure

b. Cabin Altimeter
- Shows the altitude inside the airplane
- Differential pressure gauge and cabin altimeter can be combined into one instrument

c. Cabin Rate of Climb/Descent
- Shows how quickly the cabin altitude is changing during a climb or descent



C. Oxygen Systems AI.II.E.K1l

i. Types

a. Continuous Flow
- Most common in GA planes
- Usually for passengers and has a reservoir bag which collects oxygen from the system while exhaling
- Ambient air is added to the oxygen during inhalation after the reservoir oxygen supply is depleted
- Exhaled air is released into the cabin

b. Diluter Demand
- Supply oxygen only when the user inhales through the mask

- Depending on the altitude, the regulator can provide 100% oxygen or mix the cabin air and oxygen
- The mask provides a tight seal and can be used safely up to 40,000'

c. Pressure Demand
- Like diluter demand, except oxygen is supplied under pressure at cabin altitudes > 34,000'
- Provide a positive pressure application of oxygen that allow the lungs to be pressurized with oxygen
- Safe at altitudes above 40,000'
- Some systems include the regulator on the mask to eliminate purging a long hose of air

ii. Aviator's Breathing Oxygen (Introduction to Aviation Physiology document)

a. Aviator's oxygen must meet a minimum purity requirement, excluding moisture content, of 99.5% and may not contain more than 0.005 mg of water vapor per liter
- Different limits are established for oxygen from different sources in recognition of the different ways oxygen is stored, dispensed, and used
- Recommended to use aviator's breathing oxygen, medical/industrial oxygen may not be safe

iii. Care and Storage of High-Pressure Oxygen Bottles

a. If the airplane does not have a fixed installation, portable oxygen equipment must be accessible in flight

b. Usually stored in high pressure containers at 1,800 – 2,200 psi
- When the ambient temperature surrounding the cylinder decreases, pressure within will decrease
  - a A drop in pressure may be due to being stored in an unheated area, rather than loss of oxygen
- High pressure containers should be marked with the psi tolerance before filling to that pressure
  - a The oxygen used should meet or exceed SAE AS8010, Aviation Breathing Oxygen Purity Standard

c. Be aware of the danger of fire when using oxygen
- Materials that are nearly fireproof in ordinary air may be susceptible to combustion in oxygen
  - a Oils and greases may catch fire if exposed to pure oxygen and cannot be used in oxygen systems
- Smoking during any kind of oxygen equipment use is prohibited

d. Before each flight, thoroughly inspect and test all oxygen equipment

e. To assure safety, periodic inspections and servicing should be done

19. Deice and Anti-Ice Systems AI.II.E.K1j

A. General

i. Anti-icing equipment is designed to prevent the formation of ice

ii. Deicing equipment is designed to remove ice once it has formed

iii. Protect numerous parts of the aircraft, including the leading edge of wing and tail surfaces, pitot and static ports, fuel tank vents, stall warning devices, windshields, and propeller blades

iv. Most light aircraft only have a heated pitot tube and are not certified for flight in icing

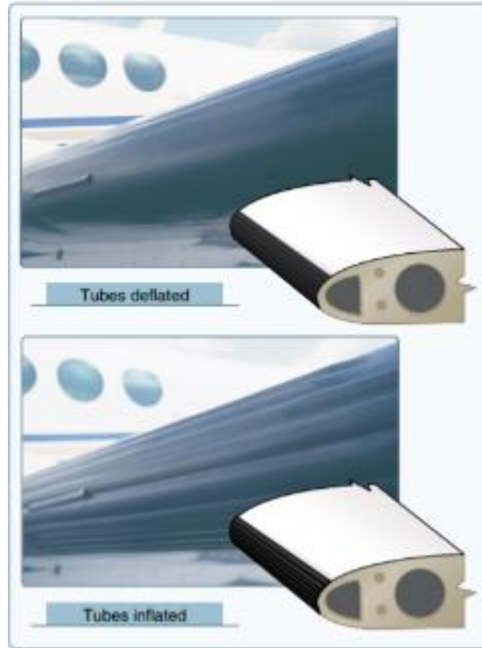
a. We'll discuss various common pieces of equipment that may not be included on your aircraft

B. Airfoil

i. Deicing Boots

a. Inflatable deicing boots consisting of a rubber sheet bonded to the leading edge of the air foil

b. Operation
- When ice builds up on the leading edge, an engine-driven pneumatic pump inflates the rubber boots
  - a Many turboprop aircraft divert engine bleed air into the wing to inflate the rubber boots
- Upon inflation, the ice is cracked and falls off the leading edge of the wing

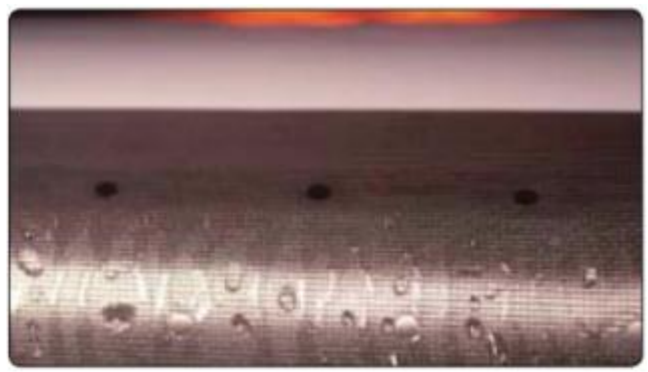


c. Controlled by a switch on the flight deck
    - Can be operated in a single cycle, or allowed to cycle at automatic, timed intervals

d. Instruments
    - Many systems use a suction and pneumatic pressure gauge to indicate proper boot operation

ii. Thermal Anti-Ice System
  a. Heat provides one of the most effective methods for preventing ice accumulation on an airfoil
  b. Operation
    - High performance turbine aircraft often direct hot air from the compressor section of the engine to the leading-edge surfaces
      a The hot air heats the leading edge sufficiently to prevent the formation of ice
    - Should be activated prior to entering icing conditions

iii. Weeping Wing
  a. Uses small holes in the leading edge of the wing to prevent the formation and build-up of ice
  b. Operation
    - An antifreeze solution is pumped to the leading edge of the wings and weeps out through the small holes



  c. Capable of deice and anti-ice
    - When ice has accumulated on the leading edges, the antifreeze solution chemically breaks down the bond between the ice and airframe, allowing aerodynamic force to remove the ice

C. Windscreen
  i. Alcohol
    a. Directs a flow of alcohol to the windscreen
    b. If used early enough, the alcohol prevents ice from building up on the windscreen
  ii. Electric Heat
    a. Small wires or other conductive material is imbedded in the windscreen
    b. Operation
      - Turned on by a switch in the flight deck
      - Causes an electric current to be passed across the shield through the wires to provide sufficient heat to prevent the formation of ice on the windscreen

D. Propeller
  i. Alcohol
    a. Used to prevent ice from forming on the leading edge of the propellers
    b. Alcohol is released from discharge nozzles and centrifugal force drives it down the leading edge of the propeller blade
      - There are also grooves in the propeller boots to help direct the flow of alcohol
  ii. Electric Heat
    a. Propellers are fitted with anti-ice boots

  b. The boots are imbedded with electrical wires that carry current for heating the propellers

20. Autopilot

- A. Overview
  - i. Automatic flight control system to keep an aircraft in level flight or on a set course
    - a. Amount of automation varies based on the system
    - b. Reference POH/operator manual for full capabilities
  - ii. Reduces pilot physical and mental demands
- B. RM: Managing & Monitoring Automation AI.II.E.R3
  - i. Managing: Automation is only as good as the inputs it's given
    - a. Understand the system's capabilities
    - b. Ensure proper set up and programming
  - ii. Monitoring: Pilot must follow along with the automation
    - a. Ensure it's doing what you intend it to do, when intended

21. RM: Abnormalities & Failures AI.II.E.K2, AI.II.E.R1

- A. Automated Systems AI.II.E.R3
  - i. Monitor associated indications and be familiar with expected operation, ranges & limitations, and warning annunciations
  - ii. Reference the POH and/or take action if indications are out of range
    - a. Ex. Pressurization system not maintaining proper differential pressure
- B. Recognizing Malfunctions or Failures
  - i. Specific to the aircraft and its operating systems, but common options include:
    - a. EFD Warning Annunciations
    - b. Caution & warning lights
    - c. Gauge indications
    - d. Abnormal operation (rough running engine, controls binding, etc.)
- C. Managing a Failure (Airborne) AI.II.E.R2
  - i. Maintain Aircraft Control
    - a. Fly the airplane - Get to a safe flight state (straight-and-level, etc.)
    - b. Trim and turn on automation, if possible
    - c. Maintain control throughout the malfunction
      - Do not let the issue, checklists, etc. distract from flying the airplane
  - ii. Analyze the Situation
    - a. Indications, lights, sounds, visual (i.e., smoke, leaks, fire, etc.), smells, etc.
    - b. Use all available information to determine the issue
  - iii. Take the Proper Action
    - a. Apply any memory items
    - b. Use the appropriate checklist from the POH
  - iv. Land, as conditions require/permit
    - a. Based on the emergency, decide on a landing area (divert, field, ditching, etc.)
    - b. This may have to occur in conjunction with the checklist(s)
- D. Managing a Failure (On the Ground)
  - i. Remain on the ground
  - ii. Analyze the situation: Same as above
  - iii. Take proper action: Run the appropriate checklist(s)
  - iv. Decide whether to continue the flight or return to park
    - a. Is the issue fixed? What are the chances of reoccurrence and the effects if it does, etc.

22. Flight Instruction (Unfamiliar Aircraft, Systems & Avionics) AI.II.E.R4

- A. Just because it's legal, doesn't mean it's safe

B. Ensure proficiency in any aircraft you're flying, let alone instructing in
   i. Important for safety as well as the learner's time, money, and education

Conclusion:
Brief review of the main points
A thorough understanding of the airplane's systems makes a safer, smarter pilot.

The airplane's attitude (rotation around the 3 axes) is controlled by deflection of the primary flight controls. When deflected, these surfaces change the camber and AOA of the wing or stabilizer and thus change its lift and drag characteristics. Trim controls are used to relieve the control pressures necessary, and flaps increase lift and induced drag and create a compromise between a high cruise speed and low landing speed.

II.E. Cessna 152

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. Useable Fuel: 24.5 gallons (standard tanks) / 37.5 gallons (long range tanks) 3. Min Oil: 4 Quarts
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

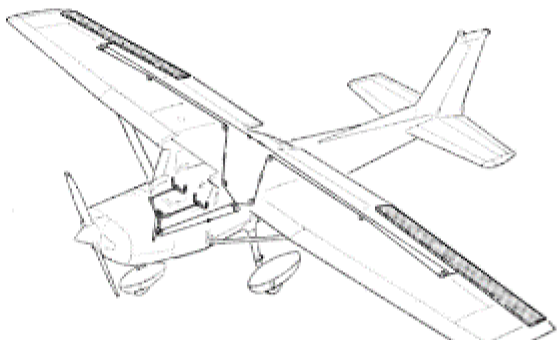
The main systems found on the Cessna 152. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

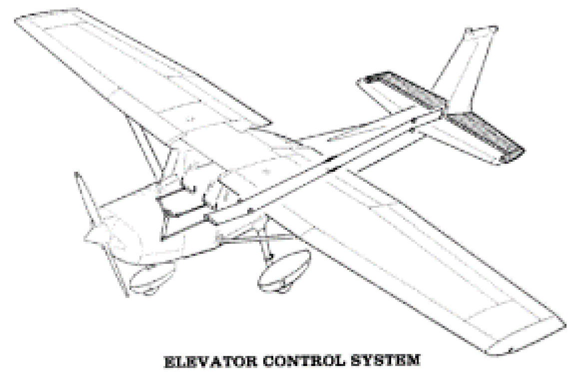
Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

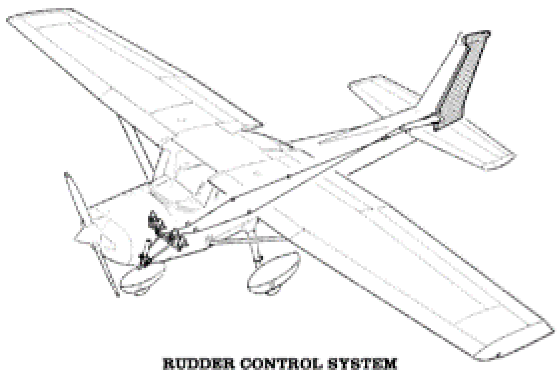
1. **Primary Flight Controls and Trim**
   - A. Primary Flight Controls
     - i. Aileron, Rudder and Elevator control surfaces
       - a. Conventional aileron, rudder and elevator control surfaces
       - b. Manually operated through cables and mechanical linkage
       - c. Control wheel for the ailerons and elevator. Rudder/brake pedals for the rudder
     - ii. Construction
       - a. Ailerons: constructed of a forward spar containing balance weights, formed sheet metal ribs and "V" type corrugated aluminum skin joined together at the trailing edge
       - b. Rudder: constructed of a formed leading edge skin containing hinge halves, a wraparound skin panel and ribs, and a formed trailing edge skin with a ground adjustable trim tab at its base. The top of the rudder incorporates a leading-edge extension which contains a balance weight
       - c. Horizontal Stabilizer: construction consists of a main spar and bellcrank, left and right wrap around skin panels, and a formed trailing edge skin on the left half of the elevator; the entire trailing edge of the right half is hinged and forms the elevator trim tab. The leading edge of both left and right elevator tips incorporate extensions which contain balance weights



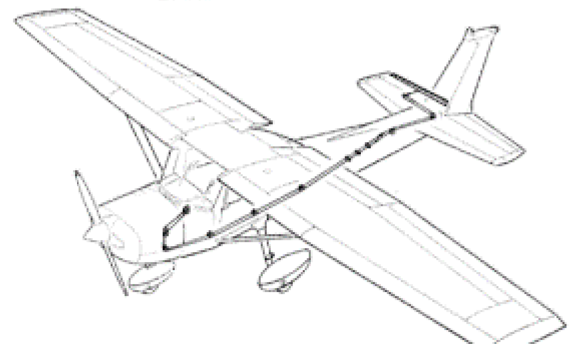
AILERON CONTROL SYSTEM



ELEVATOR CONTROL SYSTEM



RUDDER CONTROL SYSTEM



ELEVATOR TRIM CONTROL SYSTEM

- B. Trim
  - i. Manually operated elevator trim
    - a. The elevator trim tab is moved through the vertically mounted trim control wheel
    - b. Forward rotation = nose down; Aft rotation = nose up

2. Flaps

- A. Single-slotted wing flaps
- B. Operated by the wing flap switch lever
  - i. 10°, 20°, 30° settings
    - a. For flap settings greater than 10°, move the switch lever to the right to clear the stop and position it as desired
- C. A scale and pointer to the left of the control lever indicates flap travel in degrees
- D. Construction
  - i. Basically, the same as the ailerons (above), with the exception of the balance weights and the addition of a formed sheet metal leading edge section

3. Powerplant and Propeller

- A. Powerplant
  - i. Lycoming O-235-L2C
    - a. Direct Drive
    - b. Horizontally Opposed
    - c. 4 cylinders
    - d. Air Cooled
    - e. Carbureted
    - f. Wet Sump Oil System
    - g. 110 hp at 2550 rpm
  - ii. Engine Controls

a. Throttle Control (black)
   - Open in forward position
   - Closed in aft position
   - Friction lock – rotating clockwise increases throttle friction, counterclockwise decreases friction

b. Fuel Mixture (red)
   - Rich – full forward
   - Idle/Cutoff – full aft
   - Small movements can be made by rotating the knob
     a Clockwise = rich
     b Counterclockwise = lean
   - Rapid/large movements, the knob may be moved forward or aft by depressing the lock button in the end of the control and positioning the control as desired

iii. Indications

a. Engine operation is monitored by the following:
   - Oil Pressure Gauge
     a A direct oil pressure line from the engine delivers oil to the gauge
     b Normal – Green Arc (60-90 psi)
     c Min Idling Pressure – Red Line (25 psi)
     d Max Pressure – Red Line (115 psi)
   - Oil Temperature Gauge
     a Operated by an electrical-resistance type temperature sensor which receives power from the aircraft electrical system
     b Normal – Green Arc (100° – 245° F)
     c Max Temp – Red Line (245° F)
   - Tachometer
     a Indicates both engine and propeller speed
     b Normal – Green Arc (1900 to 2550 RPM)
     c Max – Red Line (2550 RPM)
     d The upper end of the green arc is "stepped" to indicate approximate RPM for 75% engine power at sea level (2350 RPM), at 4000' (2450 RPM), and at 8000' (2550 RPM)
   - Economy Mixture (EGT) indicator is also available
     a A thermocouple probe in the muffler tailpipe measures exhaust gas temperature and transmits it to the indicator

B. Propeller
   i. Two Blade, Fixed Pitch propeller
   ii. One piece, made of forged aluminum alloy
   iii. 69" diameter

4. Landing Gear

A. Tricycle Landing Gear
   i. Steerable nosewheel, and two main wheels

B. Shock absorption
   i. Main Wheels - tubular spring steel main landing gear struts
   ii. Nose Wheel - air/oil nose gear shock strut

C. Braking
   i. Each main wheel is equipped with a hydraulically actuated disk brake on each wheel
   ii. Operation
      a. Each brake is connected, by a hydraulic line, to a master cylinder attached to each of the pilot's rudder

pedals. The brakes are operated by applying pressure to the top of either the left or right set of rudder pedals, which are interconnected

- If braking action decreases during taxi or landing roll let up on the pedals and reapply with heavy pressure
- If the brakes become spongy or pedal travel increases, pumping the brakes should build up brake pressure
- If one brake weakens or fails use the other brake sparingly while using opposite rudder, as required, to offset the good brake

b. When the airplane is parked, both main wheel brakes may be set by utilizing the parking brake which is operated by a handle under the left side of the instrument panel

iii. Brake Failure

a. Symptoms of impending brake failure may include
- Gradual decrease in braking action
- Noisy or dragging brakes
- Soft or spongy pedals
- Excessive brake travel
- Weak braking action

b. If any of these symptoms appear, immediate attention is needed

5. Fuel, Oil, and Hydraulic

A. Fuel

i. Two vented fuel tanks – one tank in each wing

ii. Standard Tanks

a. Usable Fuel: 24.5 gallons

b. Unusable Fuel: 1.5 gallons

c. Total Fuel: 26 gallons

iii. Long Range Tanks

a. Usable Fuel: 37.5 gallons

b. Unusable Fuel: 1.5 gallons

c. Total Fuel: 39 gallons

d. May be serviced to a reduced fuel capacity to permit heavier cabin loadings
- Fill each tank to the bottom of the indicator on the fuel filler neck
- 12.25 usable gallons, 13 gallons total

iv. Operation

a. Gravity flows from the wing tanks to a fuel shutoff valve. With the valve in the ON position, fuel flows through a strainer to the carburetor. From the carburetor, mixed fuel and air flows to the cylinders through intake manifold tubes

b. The manual primer draws its fuel from the fuel strainer and injects it into the cylinder intake ports

v. Venting

a. Essential to system operation
- Blockage of the venting system will result in a decreasing fuel flow and eventual engine stoppage

b. Venting is accomplished by an interconnecting line from the right fuel tank to the left tank. The left tank is vented overboard through a vent line which is equipped with a check valve, and protrudes from the bottom surface of the left wing near the wing strut attach point
- The right fuel tank filler cap is also vented

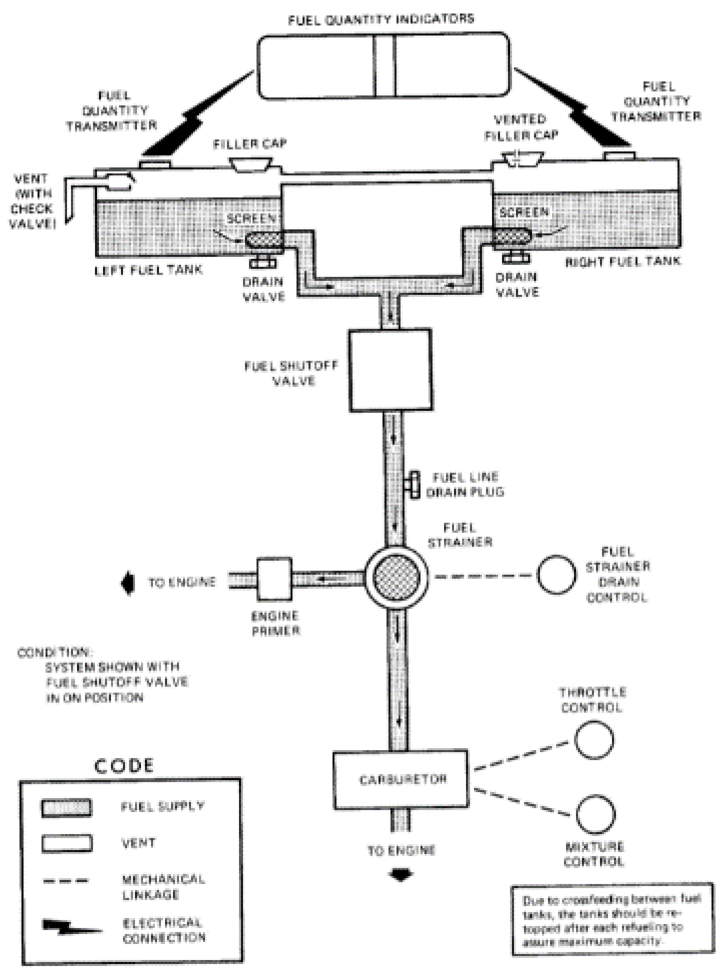
vi. Drain Valves

a. Drain valves provide a means for examination of fuel in the system for contamination and grade

b. The system should be examined before the first flight of every day and after each refueling

   c. The fuel tanks should be filled after each flight to prevent condensation
  vii. Fuel Indications
   a. Quantity is measured by two float-type fuel quantity transmitters (one in each tank) and indicated by two electrically-operated fuel quantity indicators
      - Empty – Red Line and the letter E

B. At empty, approximately .75 gallons remain in either a standard or long-range tank as unusable fuel



C. Oil
  i. Wet sump oil system
   a. Engine sump capacity – 6 quarts (one additional quart if a full flow oil filter is installed)
   b. The engine should not be operated on less than 4 quarts of oil
      - To minimize loss of oil, fill to 5 quarts for normal flights less than 3 hours
         a For extended flights, fill to 6 quarts (dipstick indication only)
  ii. Basic Operation
   a. Sump → Oil Pump → Oil Cooler → Engine → Sump
   b. Oil is drawn from the sump through a strainer screen to the engine driven oil pump. From the oil pump, oil is directly to the oil cooler and returns to the engine where it passes through the pressure screen, if the engine does not incorporate a full flow oil filter
      - If the engine is equipped with a full flow oil filter, oil passes from the pump to a thermostatically controlled bypass valve.

- a If the oil is cold, the bypass valve allows the oil to bypass the oil cooler and flow directly to the filter
- b If the oil is hot, the bypass valve routes the oil from the accessory case forward through a flexible hose to the engine oil cooler mounted on the left forward side of the engine. Returning to the accessory case, the oil passes through the filter.
- c The filtered oil then enters a pressure relief valve which regulates engine oil pressure by allowing excessive oil to return to the sump, while the balance of the pressure oil is circulated to various engine parts for lubrication. Residual oil returns to the sump by gravity flow

D. Hydraulic
  - i. There is no engine driven hydraulic system. For hydraulic information, reference 4. Landing Gear, above

6. Electrical

A. 28 V DC Electrical System

B. Power Generation
  - i. Belt driven 60 Amp Alternator
    - a. Controlled by the left half of the master switch, labeled ALT
    - b. Alternator Control Unit – alternator regulator high-low voltage control unit mounted on the engine side of the firewall
      - In the event of an over-voltage, the alternator control unit automatically shuts down the alternator leaving the battery to power the system

C. Power Storage
  - i. 24V Main Battery
    - a. Mounted on the right forward side of the firewall
    - b. Controlled by the right half of the master switch, labeled BAT

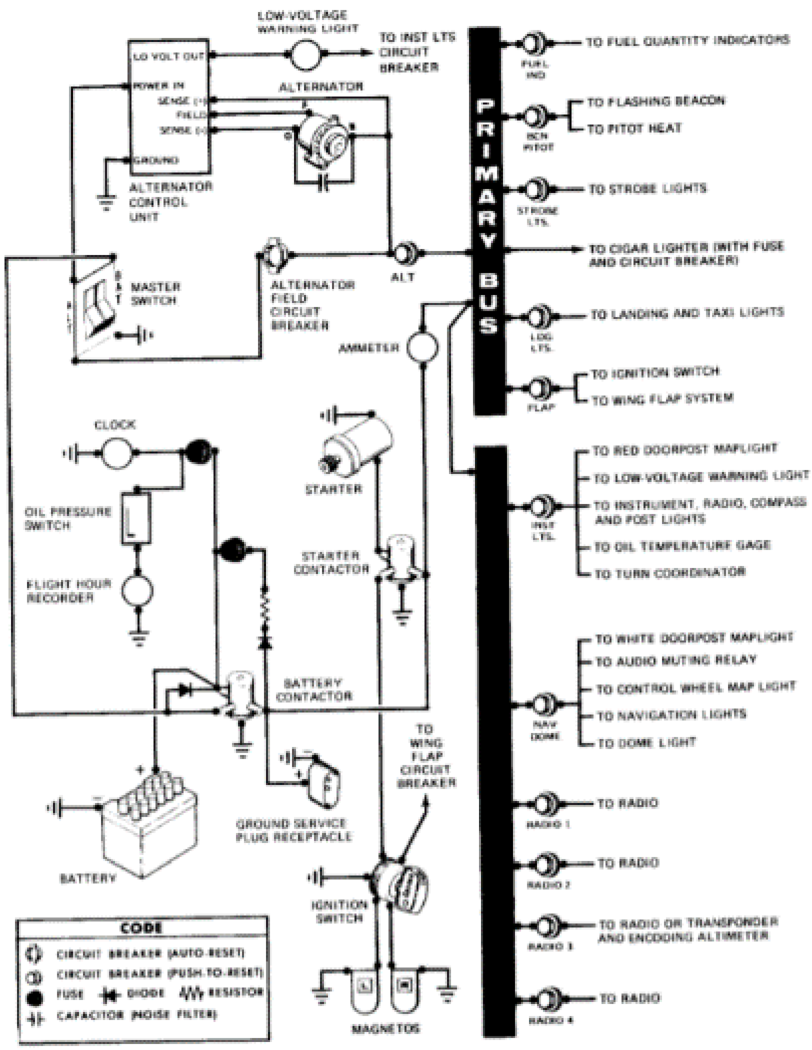
D. Power Distribution
  - i. Power is supplied to a bus bar
  - ii. The master switch controls the power to all circuits, except the engine ignition system, clock, and flight hour recorder (if installed)

E. Consumers
  - i. Individual consumers (e.g., Radio, Fuel Pump, Position Lights, etc.) are connected in series with their respective circuit breakers

F. Electrical Monitoring Instruments
  - i. Ammeter
    - a. The ammeter indicates the amount of current in amps from the alternator to the battery or the battery to the aircraft electrical system
      - When the engine is operating and the master switch is turned on, the ammeter indicates the charging rate applied to the battery
      - In the event the alternator is not functioning or the electrical load exceeds the alternator output, the ammeter indicates the battery discharge rate
  - ii. Low Voltage Warning
    - a. The low voltage warning light will illuminate when system voltage drops below normal
      - This may occur in the case that the alternator control unit senses a high voltage and shuts down the alternator
        - a The alternator control unit may be reset by turning the master switch off and back on again.
          1. If the light does not come back on again, normal alternator charging has resumed.
          2. If the light returns, a malfunction has occurred and the flight should be terminated as soon as practicable
  - iii. Circuit Breakers and Fuses
    - a. Most of the electrical circuits are protected by “push-to-reset” type circuit breakers

- The alternator, although, is protected by a "pull-off" circuit breaker

b. Fuses
   - Electrical circuits not protected by circuit breakers are the battery contactor closing circuit, clock circuit, and flight hour recorder circuit – these circuits are protected by fuses mounted adjacent to the battery



7. Avionics

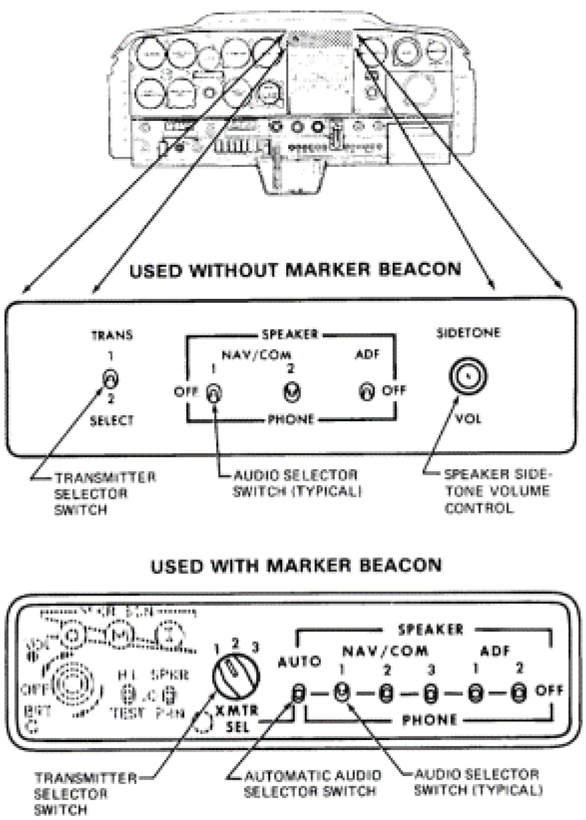
A. Avionics will vary based on model and options
   i. Operating instructions should be taken from the manuals of the respective manufacturers

B. Audio Control Panel (ACP)
   i. Two types of audio control panels are available for the 152 depending on whether the avionics package includes a marker beacon receiver
   ii. Dual transmitters – select 1 or 2 via the TRANS SELECT or XMTR switch
   iii. Headset or speaker audio
      a. Speaker – Place the switch up, in the SPEAKER position
      b. Headset – Place the switch down, in the PHONE position
   iv. NAV/COM

a. If a marker beacon receiver is not installed, audio from both NAV and COMM frequencies is combined and selected by the switches labeled NAV/COM 1 and 2
b. If a marker beacon receiver is included, separate control of NAV and Com audio is available
- NAV 1 and 2 switches select audio from the nav receivers
- COM switches select audio from communication receivers

v. COM AUTO Switch
a. If the aircraft is equipped with an ACP having marker beacon controls, a 3-position toggle switch labeled COM AUTO is provided to automatically match the NAV/COMM audio to the transmitter selected
b. In the SPEAKER position, audio from the selected transmitter will be heard on the speaker. Switching to the other transmitter automatically switches the new audio to the speaker
- The same applies to the headset audio when the switch is in the PHONE position

vi. COM BOTH Switch
a. If the aircraft is equipped with an ACP having marker beacon controls, a 3-position toggle switch labeled COM BOTH is provided to allow both COM receivers to be monitored at the same time



C. Microphone Headset Installations
i. Three headset installations were offered in the Cessna 152. Be familiar with the one installed and its operation
a. Hand held microphone and separate headset
b. Two microphone-headset installations - Padded headset, and Non Padded headset
- Microphone keying switch is located on the left grip of the pilots control wheel

8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot Static
i. General

a. Supplies ram air pressure to the airspeed indicator
b. Supplies static air pressure to the airspeed indicator, vertical speed indicator, and altimeter
c. Components
    - Unheated or heated pitot tube mounted on the lower surface of the left wing
        a Optional electrically heated pitot tube controlled by a PITOT HT switch
    - External static port on the lower left side of the forward fuselage
    - Associated plumbing to connect the pitot tube and static port to the instruments

ii. Airspeed Indicator
a. Calibrated in knots and miles per hour
b. Limitations/Range Markings
    - White Arc – 35 to 85 knots
        a Full flap operating range. Lower limit is maximum weight V_{SO} in landing configuration. Upper limit is maximum speed permissible with flaps extended
    - Green Arc – 40 to 111 knots
        a Normal operating range. Lower limit is maximum weight V_S at most forward CG with flaps retracted. Upper limit is maximum structural cruising speed
    - Yellow Arc – 111 to 149 knots
        a Operations must be conducted with caution and only in smooth air
    - Red line – 149 knots
        a Maximum speed for all operations

iii. Vertical Speed Indicator
a. Depicts aircraft rate of climb or descent in feet per minute
b. Actuated by atmospheric pressure changes resulting from changes of altitude as supplied by the static source

iv. Altimeter
a. Barometric type altimeter
b. Knob is used to adjust the barometric scale to the current altimeter setting

B. Vacuum

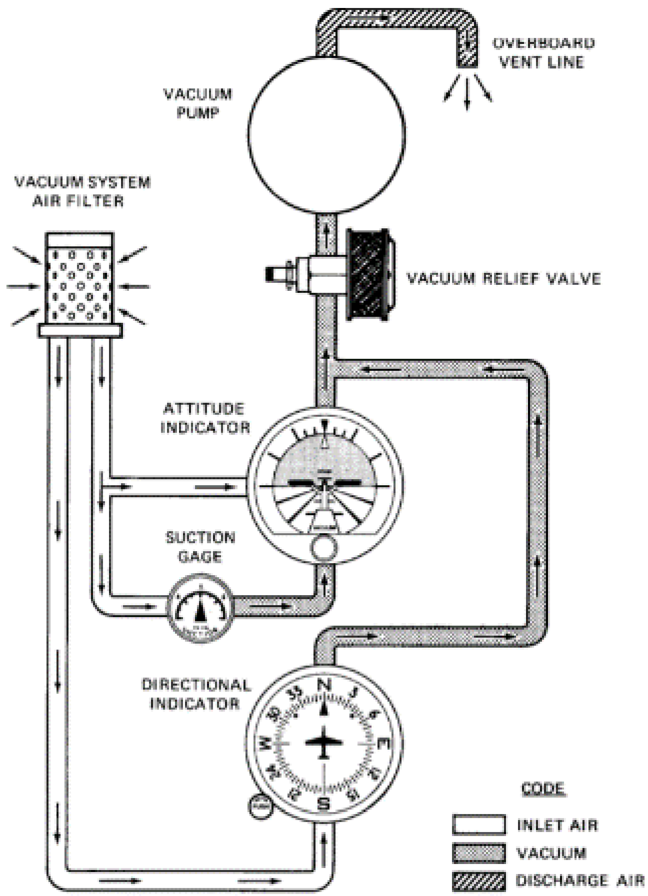
i. General
a. Engine driven vacuum system provides the suction necessary to operate the attitude indicator and directional indicator
b. Components
    - Vacuum pump
    - Vacuum relief valve
    - Air filter
    - Instruments (attitude indicator, directional gyro, and suction gauge)

ii. Attitude Indicator
a. Provides a visual indication of the aircraft's flight attitude
b. Bank is presented by a pointer at the top of the indicator
    - Index marks at 10°, 20°, 30°, 60°, 90°
    - Pitch and roll attitudes are represented by a miniature aircraft which can be adjusted via a knob at the bottom of the instrument
        a Miniature aircraft superimposed over a symbolic horizon divided into two sections by a white horizon bar
        b Upper "blue sky" and lower "ground" (brown) have arbitrary pitch reference lines useful for pitch attitude control

iii. Directional Indicator (DI)

a. Displays aircraft heading on a compass card in relation to a fixed simulated aircraft image and index
b. The DI will precess slightly over time
    - The DI should be set to match the compass just prior to takeoff, and occasionally re-adjusted on extended flights
    - A knob on the lower left edge of the instrument is used to make the adjustments

iv. Suction Gauge
a. Located on the left side of the instrument panel
b. Calibrated in inches of mercury
c. Desired range is 4.5 to 5.4 inches of mercury
    - Below this range may indicate system malfunction or improper adjustment and the indicators should not be considered reliable



9. Environmental

A. Cabin Heat and Ventilating

i. Heated air and outside air are blended together in a cabin manifold just aft of the firewall by adjustment of the heat and air controls. This air is then vented into the cabin through outlets in the cabin manifold near the pilot's and passenger's feet

ii. The temperature and volume of air cab be regulated through the push-pull CABIN HT and CABIN AIR control knobs
a. Pull the CABIN AIR knob out for ventilation
b. Pull the CABIN HT knob out to raise the temperature
    - ¼ to ½" for a small amount of cabin heat. Additional heat is available by pulling the knob out farther
    - Max heat – CABIN HT knob all the way out, and CABIN AIR knob all the way in

- No Heat – CABIN HT knob all the way in, and CABIN AIR knob all the way out

iii. Additional ventilation can be obtained by opening the adjustable ventilators near the upper left and right corners of the windshield

B. Defrost

i. Windshield defrost is supplied by a duct leading from the manifold to a pair of outlets below the windshield

10. Deicing and Anti-Icing

A. Windshield Defrost

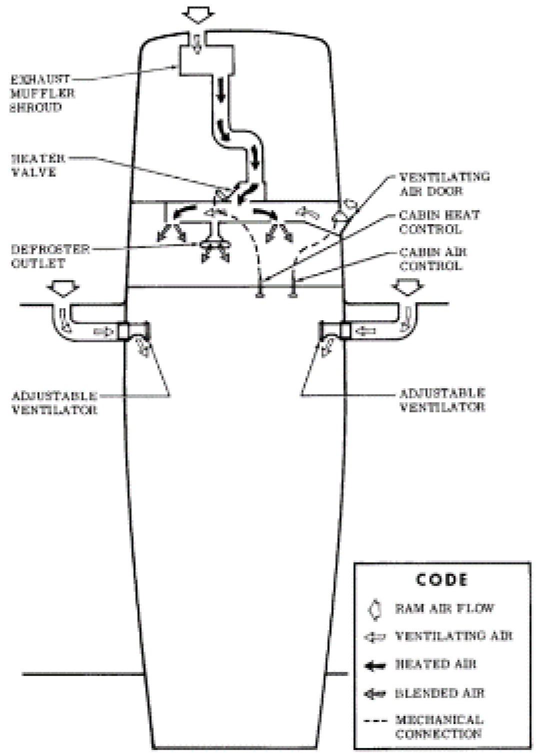
i. Windshield defrost is supplied by a duct leading from the manifold to a pair of outlets below the windshield

B. Pitot Heat

i. Electrically heated pitot tube to maintain proper operation in possible icing conditions

ii. Activated via the PITOT HT switch

a. 15-amp circuit breaker under the engine controls on the instrument panel



Conclusion:

Brief review of the main points

A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Cessna 172S G1000

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. Useable Fuel: 53 Gallons 3. Min Oil: 5 Quarts
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

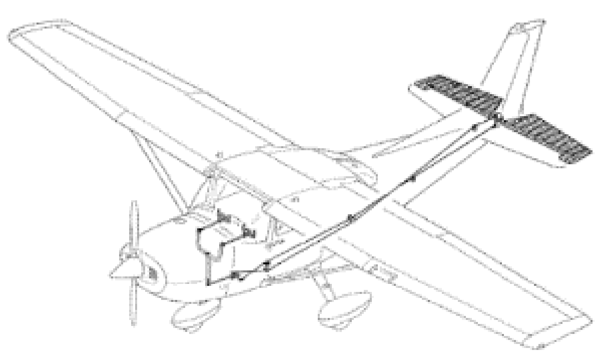
The main systems found on the Cessna 172. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

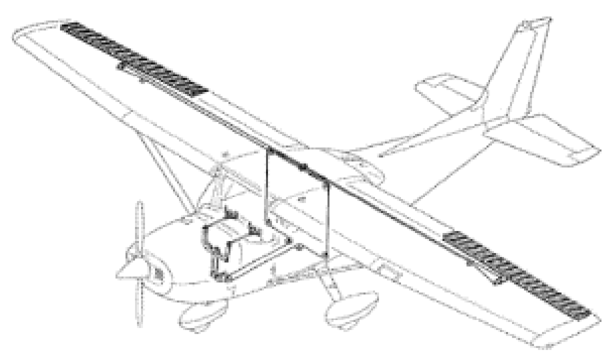
Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

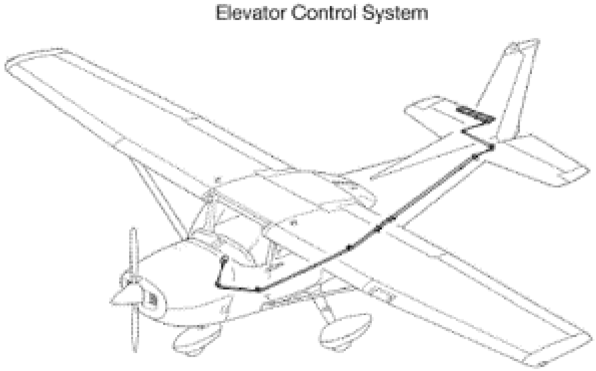
1. **Primary Flight Controls and Trim**
    A. Primary Flight Controls
        i. Aileron, Rudder and Elevator control surfaces
            a. Manually operated through cables and mechanical linkage
            b. Control wheel for the ailerons and elevator. Rudder/brake pedals for the rudder



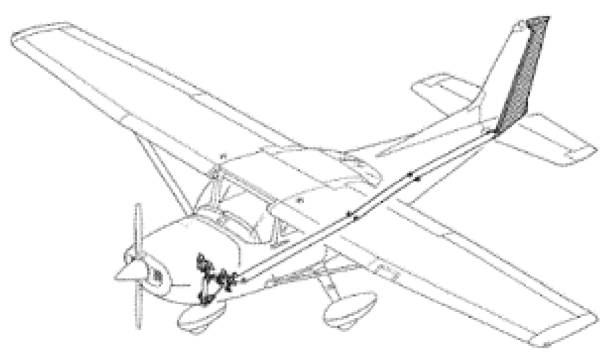
Elevator Control System



Aileron Control System



Elevator Trim Control System



Rudder Control System

B. Trim
   i. Manually operated elevator trim
      a. The elevator trim tab is moved through the vertically mounted trim control wheel
      b. Forward rotation = nose down; Aft rotation = nose up
   ii. Electric Trim, if installed
      a. Electrically adjusts the trim tab through a switch on the control wheel
   iii. Rudder trim, if installed
      a. Accomplished through a bungee connected to the rudder control system and a trim lever mounted on the control pedestal
      b. Adjusted by lifting the trim lever, then moving it left or right
         - Right trim will trim the aircraft nose right, Left trim will trim the aircraft nose left

2. Flaps
   A. Single slot type wing flaps
   B. Operated by the Wing Flap Control Lever on the instrument panel
      i. 10°, 20°, and FULL positions
   C. A scale and pointer to the left of the control lever indicates flap travel in degrees

3. Powerplant and Propeller
   A. Powerplant
      i. Lycoming IO-360-L2A
         a. Direct Drive
         b. Horizontally Opposed
         c. 4 cylinders
         d. Air Cooled
         e. Fuel Injected
         f. Wet Sump Oil System
         g. 180 hp at 2700 rpm
      ii. Engine Controls
         a. Throttle Control (black)
            - Open in Forward position
            - Closed in Aft position
            - Friction lock – rotating clockwise increases throttle friction, counterclockwise decreases friction
         b. Fuel Mixture (red)
            - Rich – full forward
            - Idle/Cutoff – full aft
            - Small movements can be made by rotating the knob
               a Clockwise = rich
               b Counterclockwise = lean
      iii. Indications
         a. G1000 Engine Indication System (EIS)
            - Vertical strip on the left of the PFD during engine starts and on the MFD during normal operation (if the MFD or PFD fails, the EIS is shown on the remaining display)
            - 3 pages
               a Engine Page – RPM, Fuel Flow, Oil Pressure, Oil Temp, EGT, VAC, Fuel Qty, Eng Hours, Volts, and AMPs
                  1. The Engine and Airframe Unit receives signals from the engine/system sensors and sends the information to the EIS which is displayed on the engine page

b Lean Page – EGT, CHT, Fuel Flow, and Fuel Qty to be used for adjusting the mixture
c System Page – Numerical values for parameters on the Engine page that are shown as indicators only. Also provides a digital value for fuel used and fuel remaining

B. Propeller
  i. Two Blade, Fixed Pitch propeller
  ii. One piece, made of forged aluminum alloy
  iii. 76” diameter

4. Landing Gear

A. Tricycle Landing Gear
  i. Steerable nosewheel, and two main wheels

B. Shock absorption
  i. Main Wheels - tubular spring steel main landing gear struts
  ii. Nose Wheel - air/oil nose gear shock strut

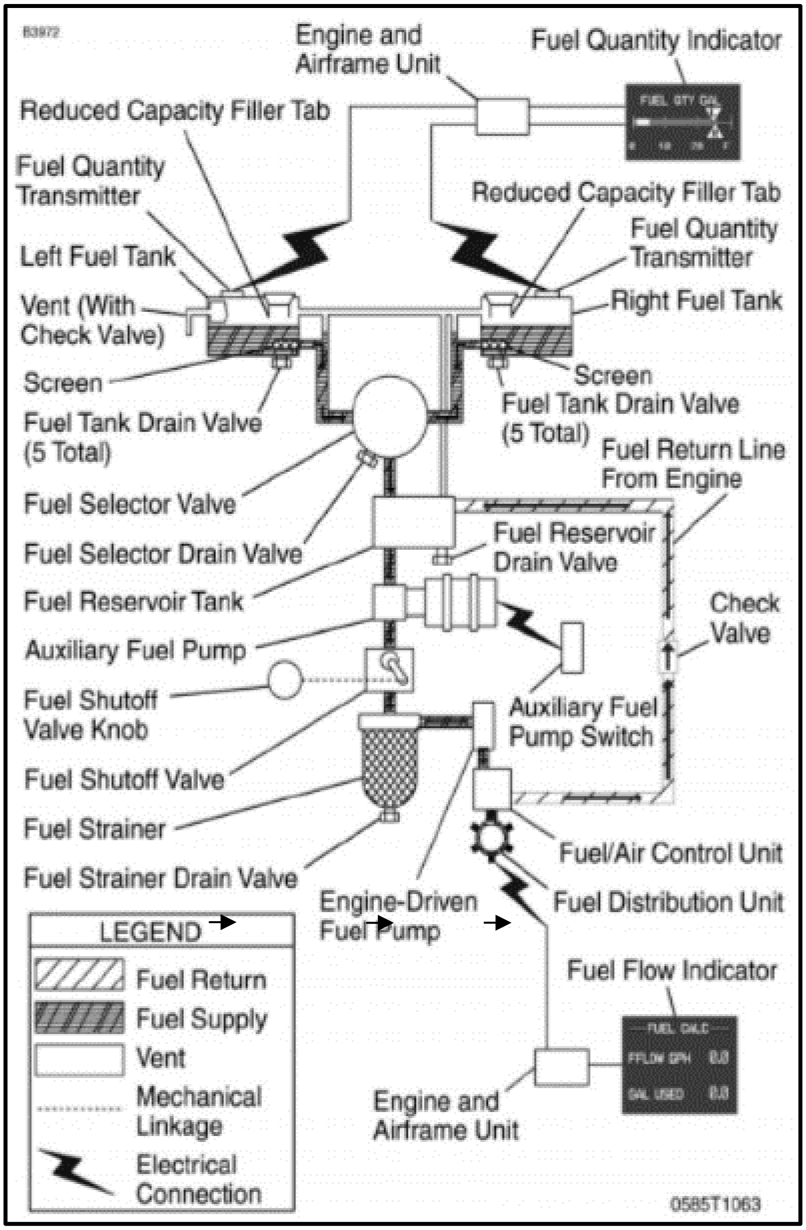
C. Braking
  i. Each main wheel is equipped with a hydraulically actuated disc brake on the inboard of each wheel
  ii. Operation
    a. Each brake is connected, by a hydraulic line, to a master cylinder attached to each of the pilot's rudder pedals. The brakes are operated by applying pressure to the top of either the left or right set of rudder pedals, which are interconnected
      - If braking action decreases during taxi or landing roll let up on the pedals and reapply with heavy pressure
      - If the brakes become spongy or pedal travel increases, pumping the brakes should build up brake pressure
      - If one brake weakens or fails use the other brake sparingly while using opposite rudder, as required, to offset the good brake
    b. When the airplane is parked, both main wheel brakes may be set by utilizing the parking brake which is operated by a handle under the left side of the instrument panel
      - To apply the parking brake, set the brakes with the rudder pedals, pull the handle aft, and rotate it 90° down
  iii. Brake Failure
    a. Symptoms of impending brake failure may include
      - Gradual decrease in braking action
      - Noisy or dragging brakes
      - Soft or spongy pedals
      - Excessive brake travel
      - Weak braking action
    b. If any of these symptoms appear, immediate attention is needed

5. Fuel, Oil, and Hydraulic

A. Fuel
  i. General
    a. Two vented integral fuel tanks – one tank in each wing
      - 53 gallons of useable fuel – 28 gallon tanks, 1.5 gallons unusable per tank
    b. Engine driven fuel pump and Electric Auxiliary Fuel Pump
      - Aux Pump is used primarily for priming the engine before start, vapor suppression in hot weather, and in the event of a failure of the engine driven pump
    c. 3 position fuel selector
      - Both, Left, Right positions

ii. Fuel Distribution
   a. Gravity flow from the wing tanks to the fuel selector and then to the fuel reservoir tank
   b. From the reservoir tank, fuel flows through the electric aux fuel pump, the fuel shutoff valve and strainer to the engine driven fuel pump
   c. From there, fuel is delivered to the fuel/air control unit which meters fuel in proportion to air and is then delivered to each cylinder

iii. Fuel Indications
   a. Two fuel sensors, one in each tank. Quantity is displayed on the EIS
      - Fuel Quantity shows the fuel available in the tank up to the limit of the sensor (24 gallons)
         a Above this limit, additional fuel may be added but will not be shown on the indicator
            1. When the fuel level decreases below 24 gallons it will be displayed on the EIS
         b A visual check of each wing tank fuel level is required prior to each flight to verify the amount of fuel in the tank vs the indicated fuel quantity
   b. Low Fuel Indications
      - Low Fuel L/R is displayed with less than 5 gallons for more than 60 seconds
         a Tone and amber indications
      - Low Fuel L/R change to flashing red hen quantity reaches the usable fuel empty level
   c. Sensor Failures
      - If the system detects a failure, the affected fuel indicator will display a red X



B. Oil
   i. Full pressure, wet sump oil system
      a. Engine sump capacity – 8 quarts, Oil filter capacity – 1 quart
      b. The engine should not be operated on less than 5 quarts of oil
         - To minimize loss of oil, fill to 8 quarts for normal flights less than 3 hours
            a For extended flights, fill to 8 quarts (dipstick indication only)
   ii. Basic Operation
      a. Sump → Oil Pump → Oil Filter → Pressure Relief Valve Oil Cooler Engine Sump
      b. Oil is drawn from the sump through a filter screen on the end of a pickup tube to the engine driven oil pump. Oil from the pump passes through a full-flow oil filter, a pressure relief valve at the rear

of the right oil gallery, and a thermostatically controlled remote oil cooler. Oil from the remote cooler is then circulated to the left oil gallery. The engine parts are then lubricated by oil from the galleries. After lubricating the engine, the oil returns to the sump by gravity.

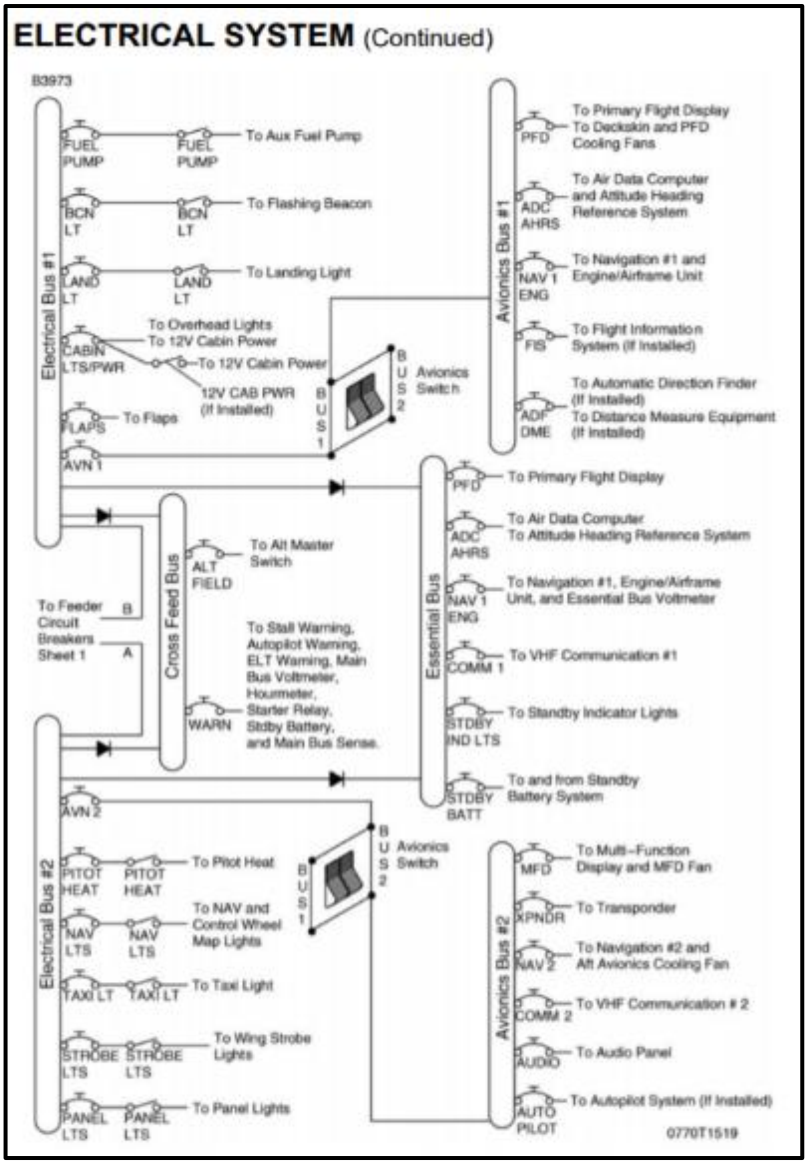
- iii. Filter Bypass
    - a. If the filter becomes plugged or the oil temperature is extremely cold, a bypass valve will cause the oil to bypass the filter

- C. Hydraulic
    - i. There is no engine driven hydraulic system. For hydraulic information, reference 4. Landing Gear, above

6. Electrical

- A. 28 V DC Electrical System
- B. Power Generation
    - i. Belt driven 60 Amp Alternator
        - a. Controlled by the ALT side of the Master switch
        - b. Alternator Control Unit (ACU)
            - Manages and monitors alternator performance. Examples include:
                - a Triggers PFD annunciations (ex. LOW VOLTS)
                - b In the event of an overvoltage condition, the ACU will automatically open the ALT FIELD CB to stop alternator output
            - Located in the Power Distribution Module (left forward side of the firewall. Power Distribution Module houses the relays used in the aircraft electrical system, the ACU, main battery current sensor, and external power connector)
- C. Power Storage
    - i. 24V Main Battery
        - a. Controlled by the BAT side of the Master switch
    - ii. Secondary (standby) Battery
        - a. STBY BATT switch can supply power for a limited amount of time to the essential bus in the event of alternator and main battery failure
            - Time remaining may be estimated by monitoring the essential bus voltage. At 20 Volts, the standby battery has little or no capacity remaining
        - b. ARM, OFF, TEST switch
            - ARM
                - a Allows the standby battery to help regulate and filter essential bus voltage during the start cycle
                - b During normal flight, it allows the standby battery to charge and be ready to power the essential bus in the event of alternator and main battery failure
            - OFF
                - a Disconnects the standby battery from the essential bus
                - b Prevents standby battery from charging and automatically providing power should an electrical system failure occur
            - TEST
                - a The energy level of the battery shall be checked before starting the engine
- D. Power Distribution
    - i. 2 Primary Buses – Electrical Bus 1 and Electrical Bus 2
        - a. Supplied with power whenever the Master Switch is turned on, and are not affected by starter or external power usage
    - ii. Essential and Crossfeed Bus
        - a. Power is supplied to most electrical circuits through the two Primary Buses with an Essential Bus and a Crossfeed Bus connected between them to support essential equipment

iii. Avionics Bus 1 and Avionics Bus 2
  a. Each Primary bus is also connected to an Avionics bus
  b. Each Avionics bus is powered when the Master & corresponding Avionics switch are On



E. Consumers
  i. Individual consumers (e.g. Radio, Fuel Pump, Position Lights, etc.) are connected in series with their respective circuit breakers

F. Electrical Monitoring Instruments
  i. Bus Voltage
    a. VOLTS for the Main and Essential buses is provided at the bottom of the EIS bar (left margin of the MFD or PFD), labeled M BUS E
      - Main Bus voltage is shown below the M. Essential Bus voltage is shown below the E
      - Normal bus voltages with the alternator operating is about 28 volts
      - Above 32 volts, the numerical value and VOLTS text turns Red
        a This indication, along with the HIGH VOLTS annunciation is an indication that the alternator is supplying too high of a voltage
          1. The ALT MASTER switch should immediately be positioned to OFF
      - Below 24.5 volts, the numerical value and VOLTS text turns Red
        a This indication, along with the LOW VOLTS annunciation is an indication that the alternator is not supplying all the power required by the aircraft
          1. If the conditions causing the LOW VOLTS warning cannot be resolved, nonessential electrical loads should be eliminated and the flight should be terminated as soon as practicable
  ii. Amps
    a. Current Amp indications for both the Main and Standby batteries is provided at the bottom of the EIS bar (along the left margin of the MFD or PFD), labeled M BATT S
      - Main Battery current is displayed below the M
        a Main battery current greater than -1.5 amps is shown in White
      - Standby Battery current is displayed below the S
        a A positive current (battery is charging) is shown in White

- b A negative current (battery is discharging) is shown in Amber
  1. In the event the standby battery is discharging, normal steady discharge should be less than 4 amps
     a. The STBY BATT annunciator will come on when discharge rates are greater than 0.5 amps for more than 10 seconds – this is an indication that the alternator and main battery are not supplying the power required by the essential bus
- In the event the alternator is not functioning, or the electrical load exceeds the output of the alternator, the main battery ammeter indicates the main battery discharge rate

iii. Circuit Breakers and Fuses
  a. Individual system circuit breakers are found on the circuit breaker panel below the pilot's control wheel
  b. All CBs on the Essential Bus, Avionics Bus 1 and Avionics Bus 2 are capable of being opened by pulling straight out for emergency electrical load management
     - Using a CB as a switch is discouraged since the practice will decrease the life of the CB
  c. All CBs on the Electrical Bus 1, Electrical Bus 2, and Crossfeed Bus are not capable of being opened
  d. Fuses
     - A fast blow automotive type fuse is used at the standby battery
     - The standby battery current shunt circuit uses two field replaceable fuses located on the standby battery controller printer circuit board

7. Avionics

A. Avionics will vary based on model and options
  i. Operating instructions should be taken from the manuals of the respective manufacturers

B. G1000
  i. PFD and MFD
     a. PFD
        - Displays
          - a Roll and pitch information, heading and course navigation information, plus attitude, airspeed, and vertical speed
          - b All communication and navigation frequencies (controls and displays)
          - c Warning/Status annunciation of aircraft systems
     b. MFD
        - Large, scalable moving map that corresponds to the aircraft's current location
          - a Various features can be displayed on the MFD (nearby aircraft, weather, lightning, etc.)
        - Principle display for all engine, fuel, and electrical system parameters
     c. Reversionary Mode
        - Places the flight information and basic engine information on both the PFD and MFD
          - a Allows the pilot full access to all necessary information should either of the display screens malfunction
  ii. Audio Panel
     a. Integrates all of the communication and navigation digital audio signals, intercom system, and marker beacon controls in one unit
        - Also controls the reversionary mode for the PFD and MFD
     b. Installed on the instrument panel between the PFD and MFD

C. G1000 Background Components
  i. Integrated Avionics Unit (GIA)
     a. Two GIAs act as the main communications hub linking all of the other peripheral parts to the displays
        - Each unit contains a GPS receiver, VHF nav receiver, VHF communication transceiver and the main system microprocessors

b. Mounted in racks in the tailcone, behind the baggage curtain

ii. Attitude and Heading Reference System (AHRS)
   a. Provides aircraft attitude and flight characteristics information to the displays and the integrated avionics units (more info below)

iii. Air Data Computer
   a. Compiles the information from the pitot-static system

iv. Engine Monitor
   a. Responsible for receiving and processing the signals from the engine and airframe sensors
   b. Transmits the information to the engine display computers

v. Transponder
   a. Provides Mode A, C, and S functions
   b. Control and operation are accomplished using the PFD
   c. Mounted in the tailcone avionics racks

vi. Weather and Radio Data Link (GDL)
   a. Provides weather information and digital audio entertainment in the flight deck
   b. Mounted in the tailcone, behind the baggage curtain

vii. Avionics Cooling Fans
   a. Four DC electric fans provide cooling for the G1000 avionics equipment
   b. A single fan in the tailcone provides cooling to the integrated avionics units and the transponder
   c. Power is provided to these fans when the BAT Master and Avionics (Bus 1 and Bus 2) switch are ON

8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot Static

i. Pitot Head
   a. Mounted on the lower surface of the left wing
   b. Electrically heated via the PITOT HEAT switch

ii. External Static Port
   a. Mounted on the left side of the forward fuselage

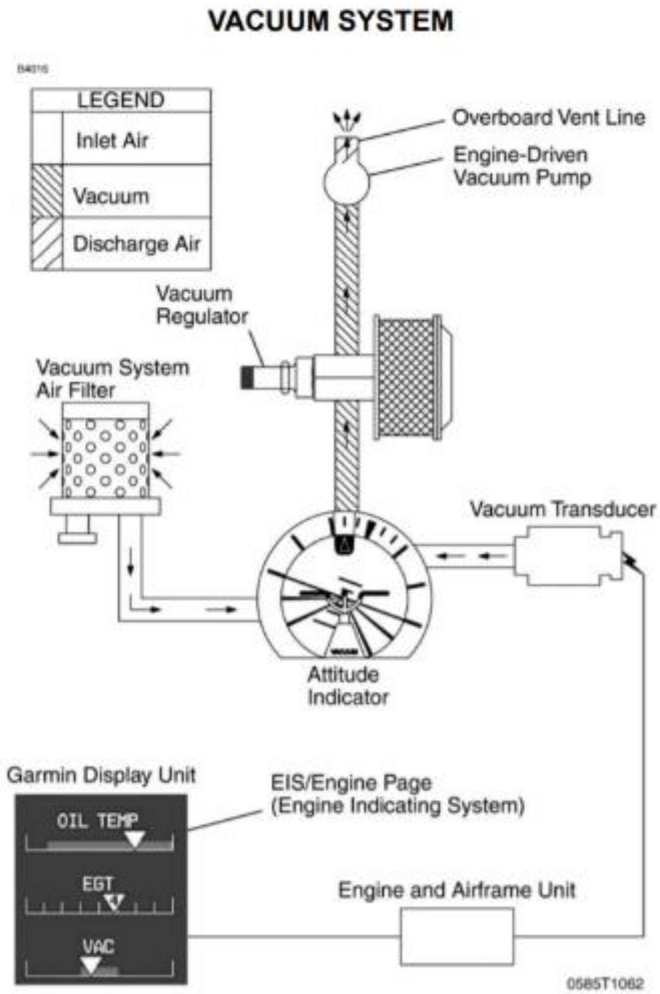
iii. Alternate Static Source
   a. Provides static pressure from inside the cabin if the external static source becomes blocked
   b. If erroneous instrument readings are suspected due to water or ice in the pressure line going to the standard external pressure source, the alternate source valve should be opened

iv. Air Data Computer (ADC)
   a. The brains of the system. Compiles information from the aircraft's pitot-static system
   b. Calculates and displays altitude, pressure altitude, airspeed, true airspeed, vertical speed, and outside air temperature

B. Vacuum

i. The vacuum system provides the vacuum necessary to operate the standby attitude indicator
   a. Consists of an engine driven vacuum pump, a vacuum regulator, the standby attitude indicator, a vacuum system air filter, and a vacuum transducer
      - Vacuum Transducer - provides the signal for the engine display on the EIS Engine page

a Amber LOW VACUUM annunciates below 3.5 in h.g.

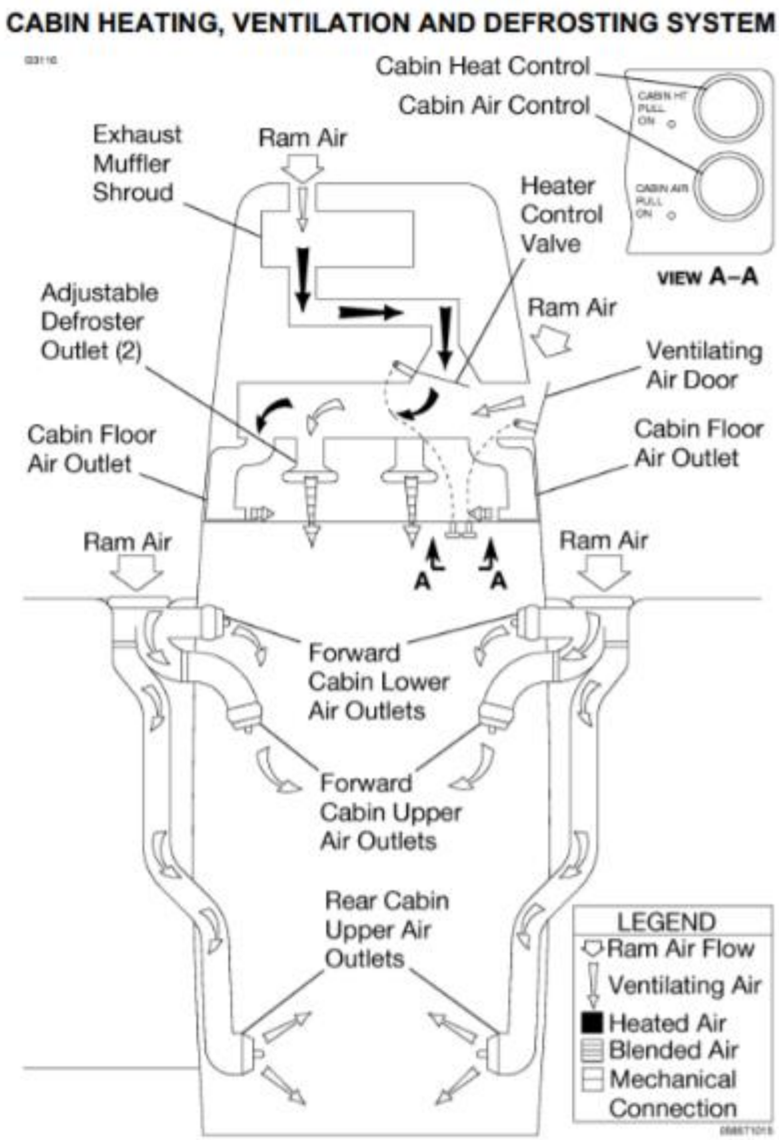


C. Attitude and Heading Reference System (AHRS)
   i. Provides aircraft attitude and flight characteristics to the G1000 display
      a. Contains accelerometers, tilt and rate sensors that replace gyros used in other aircraft
         - Heading Indicator, Attitude Indicator, Turn and Bank Indicator
      b. Magnetometer interfaces with the AHRS to provide heading information and is located in the left wing

9. Environmental

A. Control
   i. The temperature and volume of airflow into the cabin can be regulated by the push-pull CABIN HT and CABIN AIR control knobs
   ii. Cabin Ventilation
      a. CABIN AIR control knob
   iii. Cabin Heat
      a. CABIN HT control knob
         - ¼ to ½” for a small amount of heat
         - Max heat – CABIN HT pulled full out, CABIN AIR pushed full in
         - No Heat – CABIN HT pushed full in

B. Supply
   i. Front cabin heat and air is supplied by outlet holes spaced across a cabin manifold just forward of the pilot's and front passenger's feet
   ii. Rear cabin heat and air is supplied by two ducts from the manifold, one extending down each side of the cabin to an outlet just aft of the rudder pedals at floor level
   iii. Separate adjustable vents supply additional air
      a. One near each upper corner of the windshield for the pilot and front passenger
      b. Two ventilators for the rear cabin to supply air to the rear seat passengers
      c. Various additional ventilators located in various positions in the flight deck



10. Deicing and Anti-Icing

A. Windshield Defrost
   i. Defrost air is supplied by two ducts leading from the cabin manifold to defroster outlets near the lower edge of the windshield. Two knobs control sliding valves in either defroster outlet to permit regulation of defroster airflow

B. Pitot Heat

i. Electrically heated
ii. Operated through the PITOT HT switch below the lower left corner of the PFD
iii. Pitot Heat circuit breaker is at the lower left side of the pilot panel

Conclusion:
Brief review of the main points
A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Cirrus SR20

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. Prop Governor fails to Low Pitch, High RPM 3. Teledyne: 8 quart oil system / Lycoming: 7 quarts
Elements	1. Airframe 2. Primary Flight Controls and Trim 3. Flaps 4. Powerplant 5. Oil 6. Fuel 7. Propeller 8. Landing Gear 9. Electrical – G1, G2, Perspective, Perspective + 13. Avionics 14. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 15. Environmental 16. Deicing and Anti-Icing 17. Cirrus Airframe Parachute System (CAPS)
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers / References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

The main systems found on the Cirrus SR20. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

NOTE

With the various changes over the years (G1, G2, Perspective, Perspective +), the lesson attempts to differentiate between the models. In some cases, general estimates are made due to variations between serial numbers and models. Double check your POH to verify the proper information

How:

1. **Airframe**
   - A. Fuselage
     - i. Monocoque construction
       - a. Structural system in which loads are supported by an object's external skin (similar to an egg)
       - b. French for "single shell"
       - c. All flight and static loads are transferred to the fuselage structure from the wings and control surfaces through four wing attach points
     - ii. Primarily composite materials
     - iii. Composite roll cage within the fuselage provides roll protection for the occupants
     - iv. Floors are foam core composite
   - B. Wings
     - i. Constructed of composite materials producing a smooth and seamless surface
       - a. Constructed in a conventional spar, rib, and shear section (rear spars) arrangement
       - b. Upper and lower skins are bonded to the spar, ribs, and shear sections
         - Forms a torsion box that carries all of the wing bending and torsion loads
     - ii. Wing spar is one piece, continuous from wing tip to wing tip
       - a. Shear web (rear spars) are similar in construction but do not carry through the fuselage
     - iii. Cross section is a blend of several high performance airfoils
     - iv. High aspect ratio for low drag
   - C. Empennage
     - i. Consists of
       - a. Horizontal stabilizer: Single composite structure from tip to tip

b. Two-piece elevator: Aluminum
c. Vertical fin: Composite structure
d. Rudder: Aluminum

ii. All components are conventional spar (shear web), rib, and skin construction

2. **Primary Flight Controls and Trim**

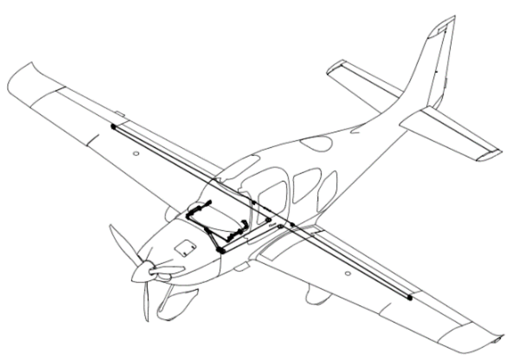
A. Ailerons

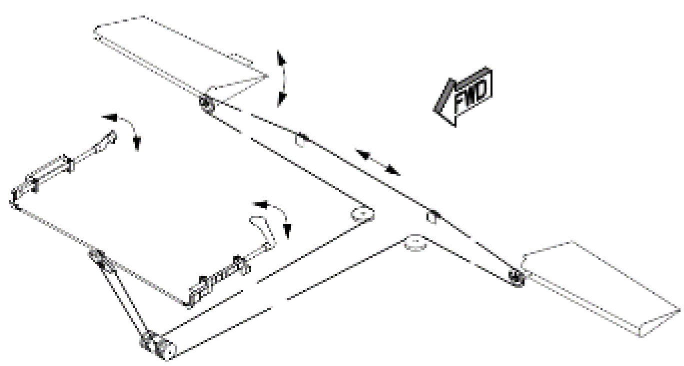
i. Provide roll control
a. Movement is controlled with the yokes
b. Push rods link the yokes to a centrally located pully sector
c. Single cable runs from the sector to the aft of the rear spar
d. From there, cables run through each wing to a crank arm that rotates the aileron

ii. Conventional design with aluminum skin, spar, and ribs

iii. Roll Trim
a. Trim Tab
- Ground adjustable trim tab installed on the right aileron
- Factory set and does not normally require adjustment

b. Electric Trim
- Electric motor adjusts the position of a spring cartridge on the left-wing pulley system
- Controlled by a trim button on the top of each yoke
  - a Moving the switch left = left wing down trim, and vice versa
- Neutral trim: Alignment of the line on the control yoke and the centering indication mark on the instrument panel
- Provides a secondary means of roll control if the primary fails
  - a Will not work if ailerons are jammed
- Also used by the autopilot to control the ailerons
- Electric trim and autopilot inputs can be overridden with normal control inputs



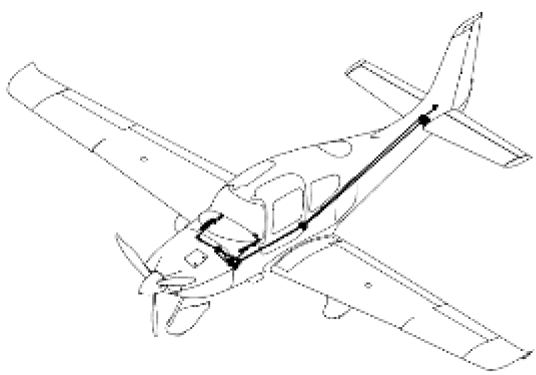


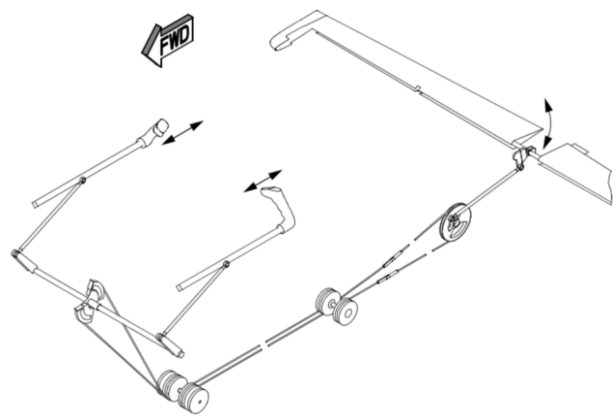
B. Elevator

i. Provides pitch control
a. Elevator movement is generated by pushing the yoke forward or pulling it backward
b. A push-pull linkage is connected to a cable sector mounted on a torque tube
c. Single cable runs from the forward elevator sector to the aft elevator sector pulley
d. Push-pull tube connects the aft elevator sector pulley to the elevator

ii. Conventional design with aluminum skin, spar, and ribs
a. Two-piece elevator
b. Each elevator half is attached to the horizontal stabilizer at two hinge points and to the fuselage tail cone

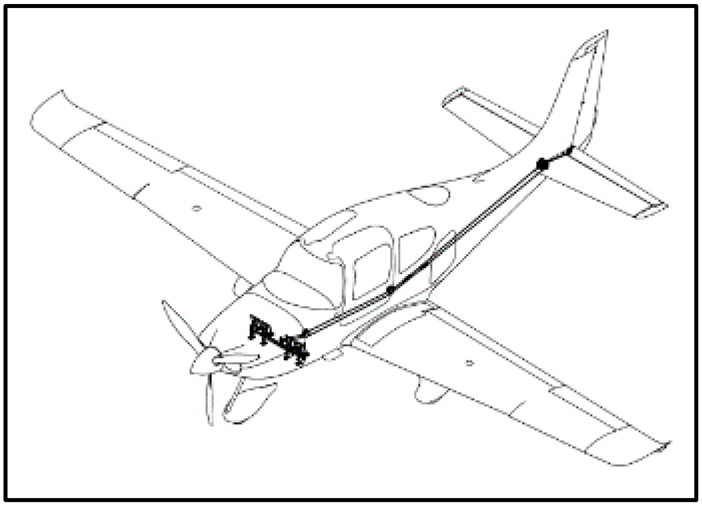
iii. Pitch Trim
  a. Trim Tab
    - Provides small adjustments to neutral trim
    - Factory set and does not normally require adjustment
  b. Electric Trim
    - Electric motor changes the neutral position of the elevator spring cartridge
    - Controlled by the trim button on the top of the control yoke
    - Switch forward = nose-down trim, and vice versa
    - Neutral Trim: Alignment of a reference mark on the yoke tube with a tab attached to the instrument panel bolster
    - Provides a secondary means of pitch control if the primary fails
      a Will not work if elevator is jammed

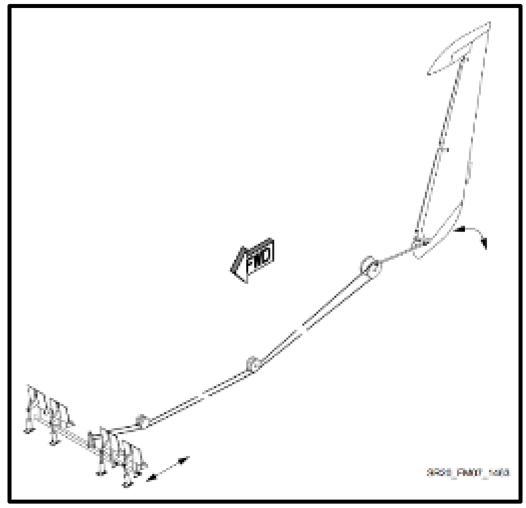




C. Rudder
  i. Provides yaw control
    a. Rudder pedals drive a single cable under the cabin floor
    b. Cable runs to a sector next to the elevator sector pulley in the aft fuselage
    c. Push-pull tube from the sector to the rudder bell crank moves the rudder right/left
    d. Springs and a ground adjustable spring cartridge tension the cables & provide a centering force
  ii. Conventional design with aluminum skin, spar, and ribs
    a. Attached to the aft vertical stabilizer at three hinge points and to the fuselage tail cone
  iii. Rudder-Aileron Interconnect (if included)
    a. Installed to provide a maximum of 8^{o} down aileron with full rudder deflection
    b. Right rudder = right roll input, and vice versa
  iv. Yaw Trim
    a. Trim Tab
      - Ground adjustable to provide small adjustments in neutral trim
      - Factory set and does not normally require adjustment
    b. Yaw Trim Spring Cartridge
      - Provided by the spring cartridge
      - Provides a centering force regardless of rudder deflection
      - Only adjustable on the ground

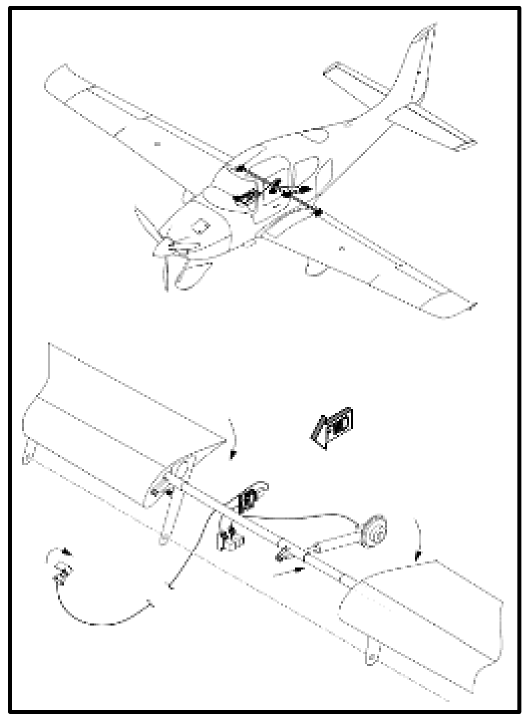
v. No control locks installed, the spring cartridges have sufficient power to act as a gust damper





3. Flaps

A. Electrically controlled, single-slotted flap
   i. Aluminum construction with 3 hinge points
B. 3 Positions: 0%, 50% (16°), 100% (32°)
   i. Flap control switch positions the flaps through a motorized linear actuator
      a. Actuator is mechanically connected to both flaps by a torque tube
      b. Actuator proximity switches limit flap travel to the desired position & provide position indication
C. Flap Control Switch
   i. Located at the bottom of the vertical section of the center console
   ii. Marked and has detents at 3 positions (Up, 50%, 100%)
      a. Corresponding VFR speed is marked at the 50% & 100% positions
   iii. Indicator light illuminates when the flaps reach the selected position
      a. Up = Green light, 50% & 100% = Yellow lights



4. Powerplant

A. Teledyne Continental IO-360-ES
   i. 6 Cylinder
   ii. Fuel Injected
   iii. Normally aspirated (no turbo or super charger)
   iv. Derated to 200 HP at 2700 RPM (sea level and ISA)
B. Perspective +: Lycoming IO-390-C3B6
   i. 4 cylinder
   ii. Fuel injected
   iii. Normally aspirated
   iv. 215 HP at 2,700 RPM
C. Air Induction System
   i. Air enters through two cowling inlets, passes through a filter, through the throttle butterfly, into the engine manifold, and then through the cylinder intake ports into the combustion chambers

- ii. If the filter becomes clogged, an alternate induction air door can be opened (details below)

D. Fuel Ignition
  - i. Two engine driven magnetos and two spark plugs in each cylinder provide fuel ignition
    - a. Right magneto fires the lower right and upper left spark plugs
    - b. Left magneto fires the upper right and lower left spark plugs
  - ii. Normal operation is conducted with both magnetos
    - a. More complete burn of the fuel-air mixture
  - iii. Perspective +: SlickSTART™
    - a. Changes ignition timing and adds energy to the spark to aid in starting
    - b. When the battery master is on, rotating the key to Start energizes the starter and SlickSTART™
      - Switch auto returns to Both when released and SlickSTART™ is deactivated

E. Cooling
  - i. Engine heat is discharged to the:
    - a. Oil and then the air passing through the oil cooler (more info in Oil section)
    - b. Air flowing past the engine (air cooling)
  - ii. Air Cooling
    - a. Air enters through two inlets in the cowling
    - b. Aluminum baffles direct the incoming air to the engine and over the cylinder cooling fins
      - Heat is transferred from the engine to the air
    - c. Air exits through two vents in the aft of the cowling

F. Exhaust
  - i. Exhaust gases are routed through the exhaust system
  - ii. After leaving the cylinders, exhaust is routed:
    - a. Through the exhaust manifold
    - b. Then to mufflers on either side of the engine
      - Lycoming engine only has a single muffler on the left side of the engine compartment
    - c. Out exhaust pipe(s) in the lower cowling
  - iii. A heat exchanger, around the right muffler, provides cabin heat (more below)
    - a. Lycoming engine has the heat exchanger around the single muffler on the left side

G. Controls
  - i. Throttle
    - a. Adjusts engine throttle setting and automatically adjusts propeller speed
    - b. Mechanically linked by cables to the air throttle body / fuel metering valve and propeller governor
      - Throttle toward Max: Opens air throttle butterfly and meters more fuel to the manifold
        - a Separate cable to the governor adjusts governor oil pressure to decrease prop pitch and maintain engine RPM
        - b System maintains approx. 2500 RPM at cruise power and 2700 RPM at full power
      - Throttle toward Idle does the opposite
  - ii. Mixture Lever
    - a. Adjusts proportion of fuel to air for combustion
    - b. Mechanically linked to the mixture control valve in the engine-driven fuel pump
      - Moving lever forward (RICH): Repositions valve allowing greater proportions of fuel
      - Moving lever aft (LEAN): Reduces proportion of fuel
      - Full aft (CUTOFF): Closes the control valve
  - iii. Alternate Air
    - a. Installed on the left console near the pilot's right knee
    - b. Used if the normal air source is suspected to be blocked

c. Operation
  - Depress the center lock button, pull the knob to the open position, release lock button
  - Pulling the knob opens the alternate air induction door on the engine induction air manifold, bypasses the air filter, allowing warm unfiltered air into the engine

iv. Friction Control Wheel
  a. On the right side of the console
  b. Used to adjust control lever resistance and feel and stability

5. Oil System

A. Wet sump, high pressure oil system provides engine lubrication and cooling

B. Operation
  i. Teledyne: 8-quart capacity sump / Lycoming: 7-quart capacity sump
    a. Wet Sump: The oil is located in a sump that is an integral part of the engine
      - Usually located at the base of the engine
      - Versus a dry sump, where the oil is stored outside the engine and pumped in
  ii. Oil leaves the sump through a suction strainer screen and is directed to the oil cooler
    a. Cooler is bypassed if oil temp is below 170º F or the pressure drop is below 18 PSI
  iii. Oil then goes through an oil filter and a pressure relief valve to the engine
    a. Oil is also directed to the propeller governor to regulate prop pitch

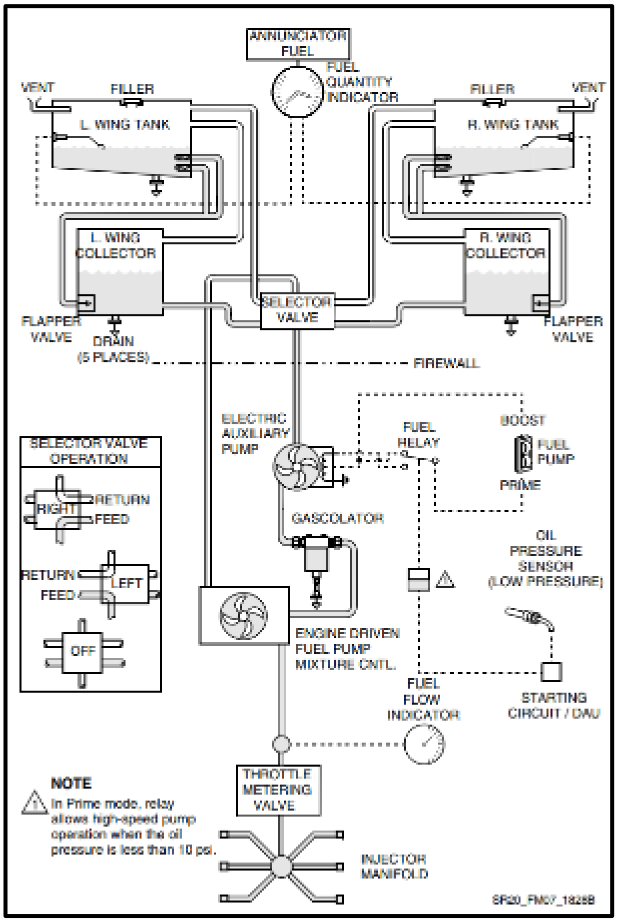
C. Oil filler cap and dipstick
  i. Teledyne
    a. Located at the left rear of the engine
    b. Engine should not be operated with less than 6 quarts of oil
      - 7 is recommended for extended flights
  ii. Lycoming
    a. Accessed through a door on the top right side of the engine cowling

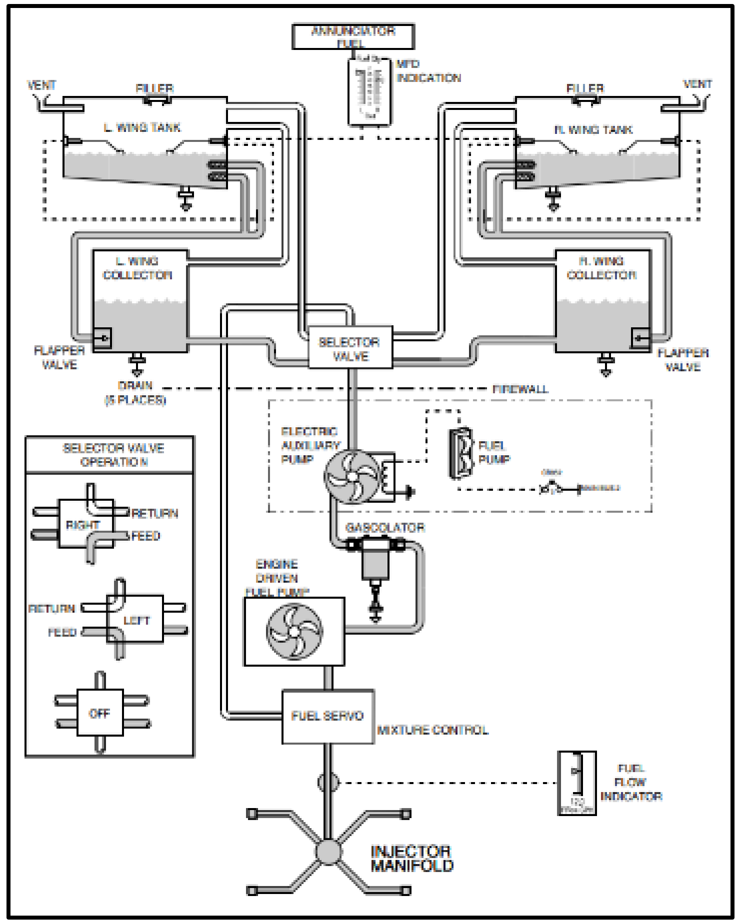
6. Fuel System

A. Tanks
  i. G1 & G2
    a. Each wing has a 28 usable gallon vented fuel tank
      - 30.3-gallon total capacity in each wing (2.3 gallons unusable)
    b. 56 total usable gallons
  ii. Perspective & Perspective +
    a. Each wing has a 28 usable gallon vented fuel tank
      - 29.3-gallon total capacity in each wing (1.3 gallons unusable)
    b. 56 total usable gallons
  iii. Collector Tanks
    a. Fuel is gravity fed to a left- and right-wing collector tank
    b. Engine driven pump pulls fuel from the collector tanks to the engine
  iv. Venting
    a. Independent NACA-type vents in each tank
      - Mounted in an access panel under each wing, near the wing tip
    b. Essential to system operation
      - Blockage would result in decreasing fuel flow and eventual engine shutoff

B. Fuel Pump
  i. Engine driven pump
    a. Primary fuel pump
    b. Runs whenever the engine is operating

        c. Pulls fuel from the collector tanks to feed fuel under pressure to the engine
    ii. Electric boost pump (Perspective + boost pump info is below)
        a. Boost pump operation and engine prime is controlled through the BOOST-PRIME switch
            - Located adjacent to the fuel selector valve
            - Oil pressure-based system controls boost pump operation
        b. PRIME position
            - Prime switch position is momentary
            - Allows the fuel pump to run at high speed when engine oil pressure is less than 10 PSI
            - Exceeding 10 PSI, pressing PRIME has no effect
        c. BOOST Position
            - Boost switch position is selectable
            - Energizes the boost pump in low-speed mode (regardless of oil pressure)
            - Delivers continuous 4-6 PSI boost to fuel flow
    iii. Perspective +
        a. Single-speed emergency fuel pump
        b. Energizes the fuel pump to deliver 23 psi boost to the fuel flow
        c. Used for priming, emergency backup, and vapor suppression in a hot fuel condition
C. Fuel Level
    i. Float-type fuel quantity sensors in each wing tank provide fuel level info to the quantity gauges
D. Fuel Selector
    i. Located at the rear of the center console
        a. Left: Allows fuel to flow from the left tank
        b. Right: Allows fuel to flow from the right tank
        c. Off: Cuts off fuel from both tanks
            - To select off, first raise the selector knob, then rotate to Off
    ii. Point the selector at the desired position
E. Drains
    i. Valves at the system low points allow draining for maintenance and fuel examination
        a. Fuel must be drained prior to every flight to check for contaminants and proper grade
        b. Drain from the wing tanks, collector tanks, and gascolator
F. Operation (Diagrams below: Left is G1, G2, & Perspective Models, Right is Perspective +)
    i. Fuel is gravity fed from each tank through strainers and a check valve to the collector tanks
    ii. Engine driven fuel pump draws fuel through a filter and the selector valve
    iii. Fuel is proportioned to the induction airflow (throttle), metered to a flow divider, and delivered to individual cylinders
        a. Perspective + (depicted below, on the right)
            - From the Selector Valve, fuel is passed to the Fuel Servo where it is proportioned based on power lever position
            - Fuel is then directed to the fuel injector manifold and then individual injector nozzles
            - System meters fuel flow in proportion to engine RPM, mixture setting and throttle angle
    iv. Excess fuel is returned to the selected tank

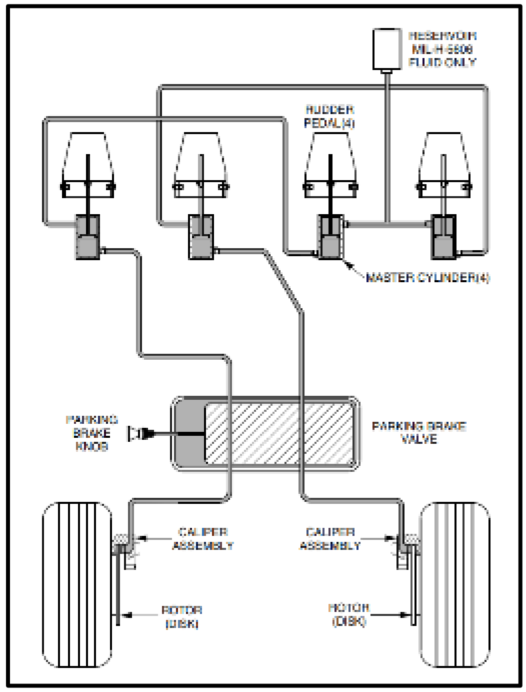




7. **Propeller**
    A. Constant speed, aluminum alloy propeller with a governor
        i. Standard: Two blade 76” diameter
        ii. Optional: Three blade 74” diameter
    B. Perspective +: Constant speed, aluminum alloy propeller with a governor
        i. Standard: Metal, 3-blade 74” diameter
        ii. Optional: Composite, 3-blade 74” diameter
    C. Governor
        i. Automatically changes propeller pitch to regulate propeller and engine RPM
            a. Uses high-pressure engine oil to adjust propeller pitch
        ii. Throttle Forward
            a. Governor meters less oil to the propeller hub
            b. Centrifugal force acts on the blades to lower pitch for higher RPM operation
        iii. Throttle Aft
            a. Governor meters more oil to the prop hub forcing the blades to a higher pitch, lower RPM
        iv. Stabilized Flight
            a. Governor automatically adjusts prop pitch to maintain the RPM setting
            b. Any change in airspeed or propeller load results in a change in propeller pitch
        v. Loss of oil pressure will result in a low pitch, high rpm setting
8. **Landing Gear**
    A. Main Gear

i. Gear struts are constructed of composite material (fatigue resistance, rugged, maintenance free)
ii. Wheels and wheel pants are bolted to the gear struts
  a. Wheel pants can be easily removed to access tires and brakes
iii. Each main gear has an independent, hydraulically operated, single-disc type brake

B. Nose Wheel
i. Tubular steel construction
ii. Free castering and can turn through an arc of approximately 170° (85° to each side)
  a. Serials 1005 thru 1885: 216° (108° to each side)



iii. Steering
  a. Accomplished by differential brake application
iv. Shock Absorption
  a. Provided by polymer shock absorbing pucks
  b. Oleo strut (Serials 2065 and later)

C. Wheel Brakes
i. Hydraulically operated, single-disc brakes on each main
ii. System consists of
  a. Master cylinder for each rudder pedal
  b. Hydraulic fluid reservoir
  c. Parking brake valve
  d. Single-disc brake assembly on each main gear
  e. Hydraulic plumbing
iii. Individually activated by pressing the top half of the rudder pedal (toe brake)
  a. Pressing the right toe brake actuates the right main wheel brake, and vice versa
iv. Temperature Sensor (Serials 2016 and later)
  a. Temp sensor mounted to each brake assembly
  b. Provides brake temps to the avionics system for caution/warning annunciations

D. Parking Brake
i. Park Brake knob is located on the left side of the console near the pilot's right ankle
ii. Setting the Parking Brake
  a. Set the brakes using the toe brakes, then pull the Park Brake knob out
  b. When the handle is pulled out, hydraulic pressure is held, locking the brakes
  c. With the knob pushed in, valve poppets are held open allowing normal brake operation

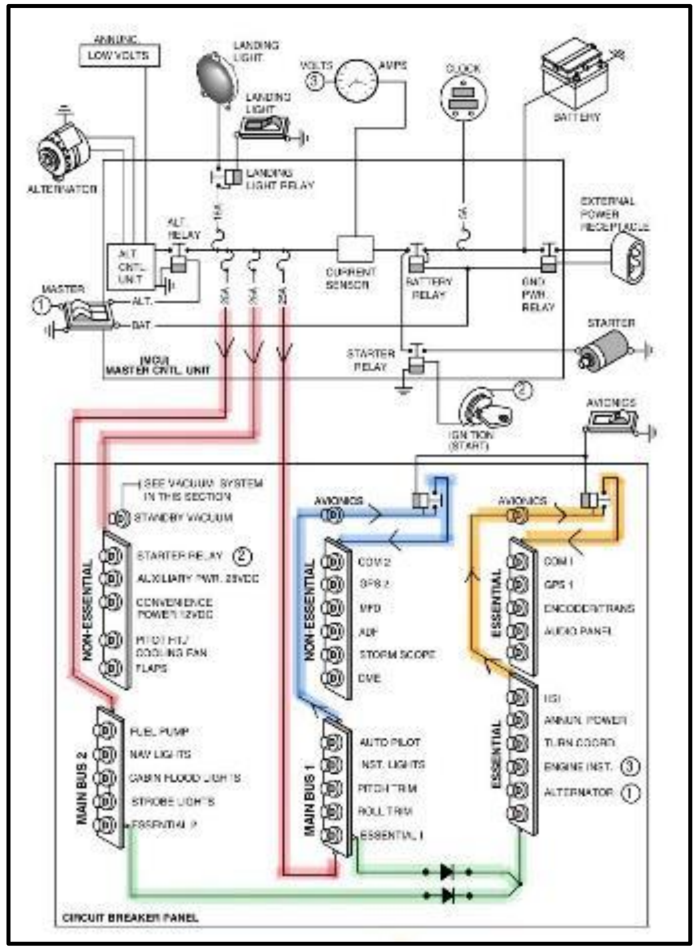
9. Electrical – G1

A. 28-VDC, negative ground electrical system

B. Power Generation
i. 75-amp alternator
ii. Provides:
  a. Primary power to the aircraft electrical system during normal system operation
  b. Constant charging current for the battery
iii. Voltage Regulator
  a. Provides transient suppression and constant voltage regulation of the alternator power

C. Power Storage
  a. Main Battery
    - 12-cell, lead-acid, 24-volt, 10-amp-hour battery
    - Used for engine starting and as an emergency power source if the alternator fails

D. Power Distribution
   i. Consists of
      a. Master Control Unit
         - Electrical power Bus
      b. Circuit Breaker Panel
         - Main Bus 1
         - Main Bus 2
         - Non-Essential Bus
         - Non-Essential Avionics Bus
         - Essential Power Bus
         - Essential Avionics Bus
   ii. Operation
      Note: POH text is a little difficult to follow so the diagram is color coded to match the text below
      a. Main Bus 1 & 2 and the Non-Essential Bus are powered by the power generation system (Alt & Bat)
      b. Main Bus 1 & 2 power Essential Bus
      c. Main Bus 1 powers Non-Essential Avionics bus
      d. Essential Power Bus powers Essential Avionics bus
   iii. Protection
      a. Over-Voltage Protector
         - Monitors the primary power bus & limits peak voltage to 28.5V
         - Provides a warning to the pilot during sustained over- and under-voltage periods



E. Electrical Monitoring Instruments
   i. Volt / Amp meter
      a. On the right instrument panel
      b. Volt Pointer
         - Scale from 16-32 volts
         - Measured off the Essential Bus
      c. Amp Pointer
         - Scale from -60 to +60 amps
         - Measured from current shunt in the MCU
         - With the engine operating and the Master switch is On, the ammeter indicates the charging rate applied to the battery
            a If the alternator fails or the electrical load exceeds the alternator output, the ammeter indicates battery discharge rate
   ii. Low Volts Warning Light
      a. Left side of the instrument panel
      b. Low Volts warning light illuminates when the voltage drops below 25.5 ± 0.35 Volts
      c. Operated by the alternator control unit in the MCU
         - If there is an over voltage, the ACU shuts down the alternator
         - Battery powers the system and discharge rate is displayed on the ammeter

d. Low RPM can trigger the light (ex. Low RPM taxi)
  - Master switch does not need to be cycled in this situation
  - Increase RPM

10. Electrical – G2

A. 28-VDC, negative ground electrical system

B. Power Generation

i. Two alternators controlled by a Master Control Unit (MCU)

a. Alternator 1
  - 75-amp belt driven alternator
  - Mounted on the right front of the engine
  - Regulated to 28 volts
  - Output is connected to the Main Distribution Bus in the MCU

b. Alternator 2
  - 20-amp gear driven alternator
  - Mounted on the accessory drive at the rear of the engine
  - Regulated to 28.75 volts
  - Output is connected to the Essential Distribution Bus in the MCU

ii. Both alternators are self-exciting, but not self-starting

a. Battery voltage is required for field excitation to start up

b. The batteries and alternators should not be turned off in flight

C. Power Storage

i. Two batteries

a. Battery 1
  - 12-cell, lead-acid, 24-volt, 10-amp-hour battery
  - Mounted on the right firewall
  - Charged from the Main Distribution Bus in the MCU (ALT 1)

b. Battery 2
  - Composed of two 12-volt, 7-amp-hour, sealed, lead-acid batteries connected in series to provide 24 volts
  - Located in a vented, acid-resistant container behind the aft cabin bulkhead
  - Charged from the circuit breaker panel Essential Bus

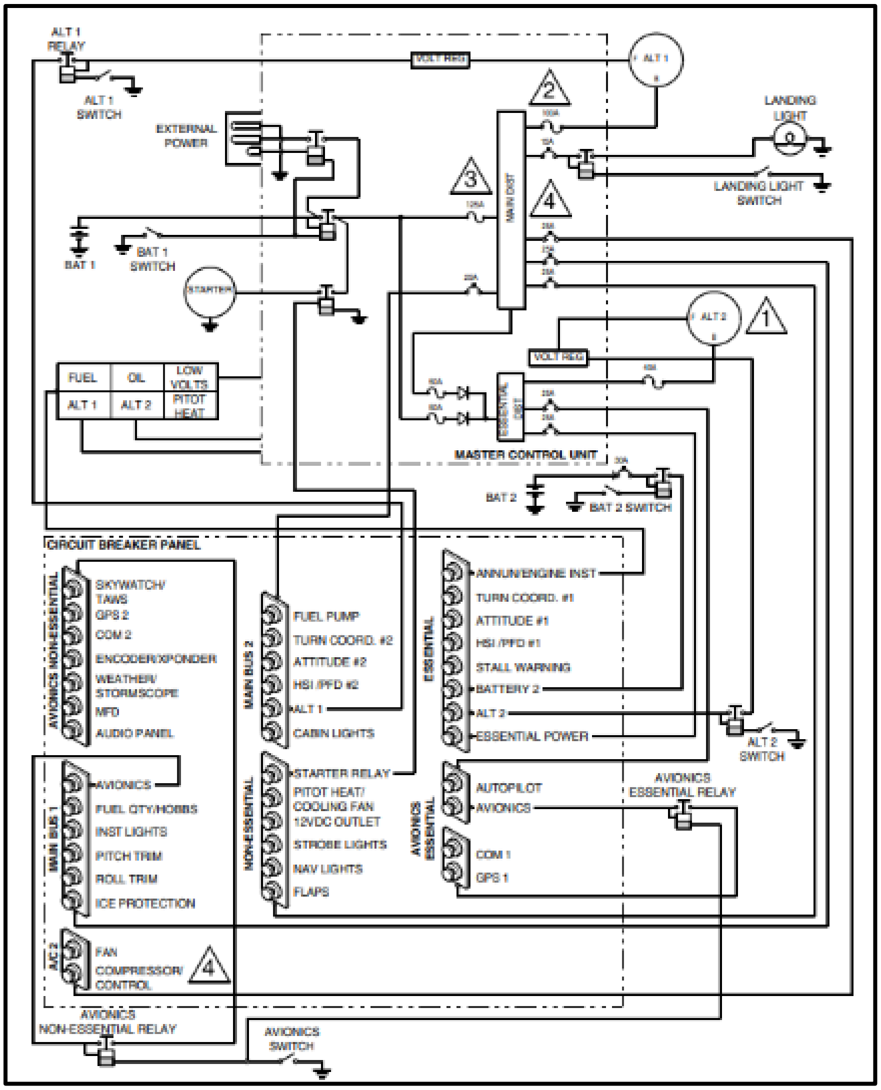
ii. In the event of an alternator failure, the battery provides the system with electrical power

D. Power Distribution

i. Consists of

a. The Main Distribution Bus and Essential Distribution Bus in the MCU

b. Associated buses in the Circuit Breaker (CB) panel
  - Main Bus 1
  - Avionics Non-Essential Bus
  - Main Bus 2
  - Non-Essential Bus
  - Essential Bus
  - Avionics Essential Bus
  - A/C2 Bus



ii. Operation
   a. Essential Buses in the CB panel are powered from the Essential Distribution Bus in the MCU
      - Essential Distribution Bus is normally powered by ALT 2
      - BAT 2 is connected directly to the Essential Bus in the CB panel
         a Bat 2 will power the bus if the voltage coming from the MCU distribution buses drops below the battery voltage
      - If ALT 2 fails, the CB panel Essential Bus will be powered from ALT 1
         a Power comes through the Main Distribution and Essential Distribution buses in the MCU
   b. Main Bus 1, Main Bus 2, and the equipment Non-Essential Bus are powered from ALT 1 through the Main Distribution Bus in the MCU
      - The Avionics Non-Essential Bus is powered from Main Bus 1

E. Consumers
   i. Individual consumers (e.g. radio, fuel pump, lights, etc.) are connected to the CB panel buses

F. Electrical Monitoring Instruments
   i. Combo Volts and Ampere meter
      a. Mounted on the right instrument panel
      b. Volt Pointer

- Scale from 16-32 volts
- Voltage is measured off the Essential Bus

c. Amp Pointer
- Scale from -100 to +100 amps
- Amps are measured from current transducers located in the MCU
- Output from each alternator and BAT 1 is measured
  - a AMMETER SELECT switch is used to select the desired indication
- With the engine operating and the ALT 1 & 2 Master switches On, the ammeter indicates the charging rate applied to the batteries
  - a If the alternators fail or the electrical load exceeds the alternator output, the ammeter indicates BAT 1 discharge rate

ii. Serials 1582 and Subsequent
a. Main & Essential Bus voltages are shown as text in the electrical data block of the MFD
b. If Main Bus voltage is < 24.5v or > 32v, the MFD will display a "Check Main Bus" in a yellow box
c. If Essential Bus voltage is < 24.5v or > 32v, the MFD will display "Check Main Bus" in a red box
d. Alternator 1 & 2 output is shown as text in the electrical data block of the MFD
- If Alt 1 or 2 output is < 2 amps for 20 seconds or more, the MFD will display "Check ALT X" in a yellow advisory box

iii. ALT Fail Caution Lights
a. Two ALT Fail caution lights (ALT 1 and ALT 2)
b. Illuminates for alternator failure or overcurrent condition

iv. Low Volts Warning Light
a. Illuminates when the voltage drops below 24.5 Volts

11. Electrical System – Perspective

A. 28-Volt DC electrical system

B. Power Generation

i. Two alternators controlled by a Master Control Unit (MCU)
a. Alternator 1
- 75-amp belt driven alternator
- Mounted on the right front of the engine
- Output is connected to Main Distribution Bus 1 in the MCU

b. Alternator 2
- 40-amp gear driven alternator
- Mounted on the accessory drive at the rear of the engine
- Output is connected to Main Distribution Bus 2 in the MCU

ii. Both alternators are self-exciting, but not self-starting
a. Battery voltage is required for field excitation to start up
b. The batteries and alternators should not be turned off in flight

C. Power Storage

i. Two batteries
a. Battery 1
- 12-cell, lead-acid, 24-volt, 10-amp-hour battery
- Mounted on the right firewall
- Charged from Main Distribution Bus 1 in the MCU (ALT 1)

b. Battery 2
- Composed of two 12-volt, 7-amp-hour, sealed, lead-acid batteries connected in series to provide 24 volts

- Located in a vented, acid-resistant container behind the aft cabin bulkhead
- Charged from the circuit breaker panel Essential Bus 1

D. Power Distribution
   i. Power is supplied through 3 distribution buses in the MCU
      a. Main Distribution Bus 1
      b. Main Distribution Bus 2
      c. Essential Distribution Bus
      d. The 3 distribution buses power the associated buses on the CB panel
   ii. Master Control Unit (MCU)
      a. Controls Alt 1 & 2, the starter, landing light, external power, and power generation functions
      b. Provides external power reverse polarity protection, alternator overvoltage protection and system health annunciations
   iii. Main Distribution Bus 1
      a. Output from Alt 1 is connected to Main Distribution Bus 1
      b. Directly powers the landing light & 3 CB buses:
         - A/C Bus 1
         - A/C Bus 2
         - Main Bus 3
   iv. Main Distribution Bus 2
      a. Output from Alt 2 is connected to Main Distribution Bus 2
      b. Powers 3 CB buses:
         - Non-Ess Bus
         - Main Bus 1
         - Main Bus 2
   v. Essential Distribution Bus
      a. Fed by both Main Distribution Bus 1 & 2
      b. Powers 2 CB buses
         - Ess Bus 1
         - Ess Bus 2
   vi. Constant Power Bus (Serials 2241 & subs)
      a. Fed by Bat 1 in the MCU
      b. Just the Conv Lights CB (Convenience Lighting)
      c. Depicted below, in the diagram on the right

E. System Protection
   i. Essential Buses 1 & 2
      a. Powered directly by Alt 1 & 2
      b. If Alt 1 or 2 fails, the remaining alternator will continue to power the buses
      c. If both Alt fail, Bat 1 will power both buses
      d. If both Alt and Bat 1 fail, Bat 2 is connected directly to Ess Bus 1
   ii. Main Buses
      a. Main Bus 1 & 2 are powered by Alt 2
         - If Alt 2 fails, Alt 1 & Bat 1 can power the buses from Main Distribution Bus 2 via the interconnecting diode
      b. Main Bus 3 is powered by Alt 1 and Bat 1
         - If Alt 1 fails, Bat 1 will power the bus
         - Alt 2 is prevented from powering the buses by the isolation diode between MC Distribution Bus 1 & 2 (power can only flow from Main Dist. Bus 1 to Main Dist. Bus 2)

iii. Non-Essential Buses
   a. Non-Ess Bus is powered by Alt 2
      - If Alt 2 fails, Alt 1 & Bat 1 can power the bus from Main Distribution Bus 2 via the interconnecting diode
   b. A/C Bus 1 & 2 are powered by Alt 1 and Bat 1
      - If Alt 1 fails, Bat 1 will power the buses
      - Alt 2 is prevented from powering the buses by the isolation diode between MC Distribution Bus 1 & 2

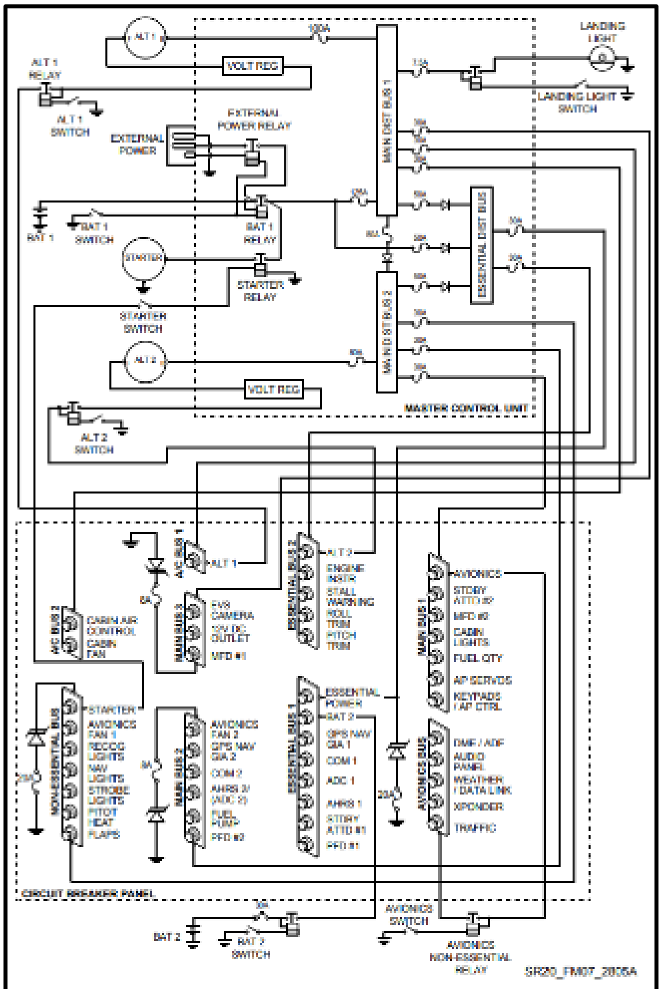


Figure 7-11
Electrical System Schematic - *Serials 2016 thru 2240 (1 of 2)*

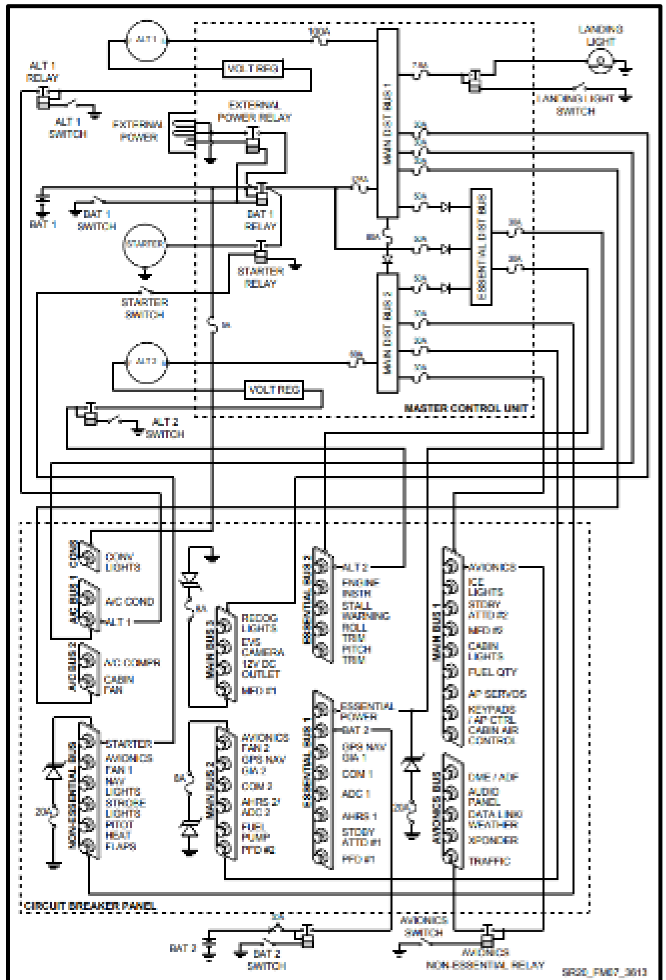


Figure 7-11
Electrical System Schematic - *Serials 2241 & subs (2 of 2)*

F. Electrical Indicating
   i. Displayed as bar graphs and text on the MFD's Engine page
      a. Engine Airframe Unit acquires the data and sends it to the Engine Indicating System for display
   ii. If the Engine page is not active, or is in backup mode, Battery 1 amp output and Ess Bus Voltage output are displayed on the left edge of the display
   iii. Electrical System Annunciations
      a. Health, caution & warning messages are displayed in the Crew Alerting System (CAWs) window
         - Color coded
         - Affected parameter on the Engine page changes to the same color as the CAWs alert
   iv. More info in Section 3 – Emergency Procedures & 3A – Abnormal Procedures

12. Electrical – Perspective +

A. 28-Volt DC electrical system
B. Power Generation
  i. Two alternators controlled by a Master Control Unit (MCU)
    a. Alternator 1
      - 100-amp belt driven alternator
      - Mounted on the right front of the engine
      - Output is connected to the Main Distribution Bus 1 in the MCU
    b. Alternator 2
      - 70-amp gear driven alternator
      - Mounted on the front left of the engine
      - Output is connected to Main Distribution Bus 2 in the MCU
  ii. Both alternators are self-exciting, but not self-starting
    a. Battery voltage is required for field excitation to start up
    b. The batteries and alternators should not be turned off in flight
C. Power Storage
  i. Two batteries
    a. Battery 1
      - 12-cell, lead-acid, 24-volt, 11-amp-hour battery
      - Mounted on the right firewall
      - Charged from Main Distribution Bus 1 in the MCU (ALT 1)
    b. Battery 2
      - Composed of two 12-volt, 7-amp-hour, sealed, lead-acid batteries connected in series to provide 24 volts
      - Located in a vented, acid-resistant container behind the aft cabin bulkhead
      - Charged from the circuit breaker panel Ess Bus 1
D. Power Distribution
  i. Power is supplied through 3 distribution buses in the MCU
    a. Main Distribution Bus 1
    b. Main Distribution Bus 2
    c. Essential Distribution Bus
    d. The 3 distribution buses power the associated buses on the CB panel
  ii. Master Control Unit (MCU)
    a. Controls Alt 1 & 2, the starter, landing light, external power, and power generation functions
    b. Provides external power reverse polarity protection, alternator overvoltage protection and system health annunciations
  iii. Main Distribution Bus 1
    a. Output from Alt 1 is connected to Main Distribution Bus 1
    b. Directly powers 3 CB buses:
      - A/C Bus 1
      - A/C Bus 2
      - Main Bus 3
  iv. Main Distribution Bus 2
    a. Output from Alt 2 is connected to Main Distribution Bus 2
    b. Powers 3 CB buses:
      - Non-Ess Bus
      - Main Bus 1

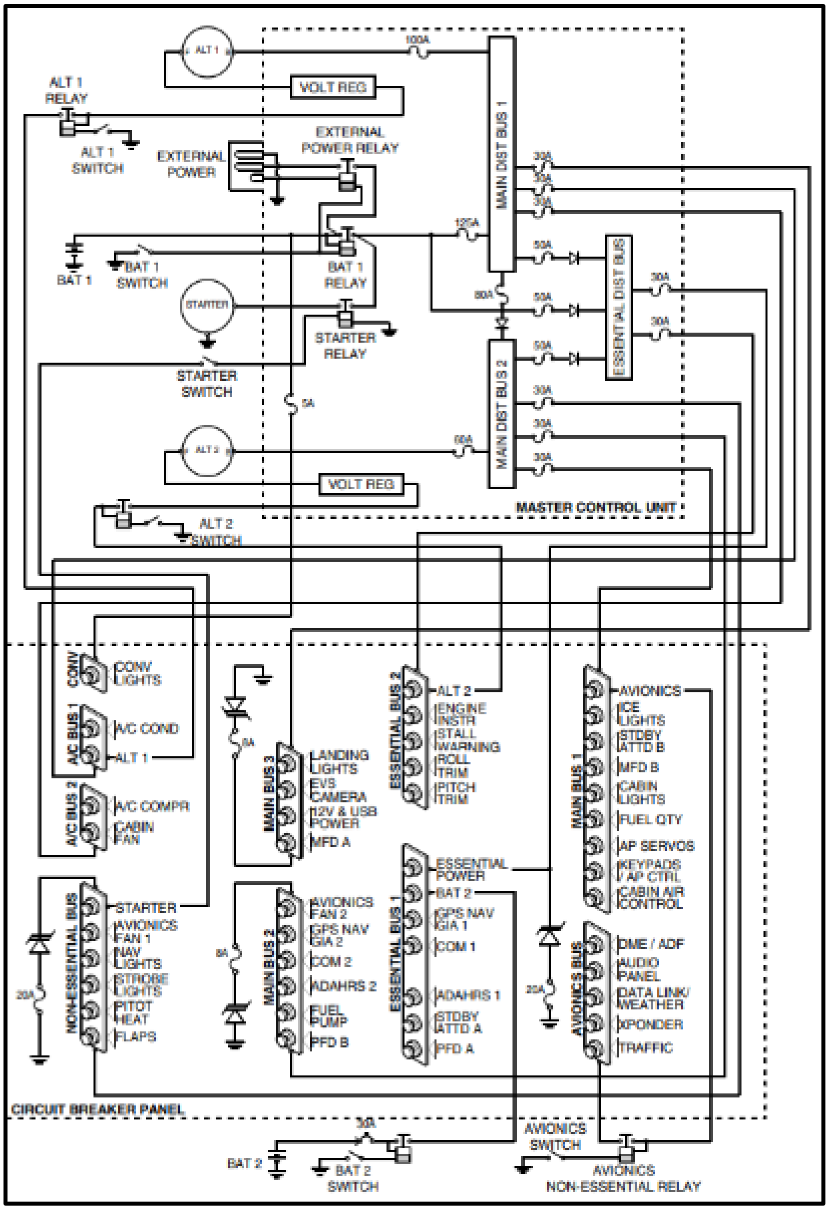
- Main Bus 2

v. Essential Distribution Bus
  a. Fed by both Main Distribution Bus 1 & 2
  b. Powers 2 CB buses
    - Ess Bus 1
    - Ess Bus 2

vi. Constant Power Bus (CONV)
  a. Fed by Bat 1 in the MCU
  b. Just the Conv Lights CB (Convenience Lighting)

E. System Protection
  i. Essential Buses 1 & 2
    a. Powered directly by Alt 1 & 2
    b. If Alt 1 or 2 fails, the remaining alternator will continue to power the buses
    c. If both Alt fail, Bat 1 will power both buses
    d. If both Alt and Bat 1 fail, Bat 2 is connected to and will power Ess Bus 1
  ii. Main Buses
    a. Main Bus 1 & 2 are powered by Alt 2
      - If Alt 2 fails, Alt 1 & Bat 1 can power the buses from Main Distribution Bus 2 via the interconnecting diode
    b. Main Bus 3 is powered by Alt 1 and Bat 1
      - If Alt 1 fails, Bat 1 will power the bus
      - Alt 2 is prevented from powering the buses by the isolation diode between MC Distribution Bus 1 & 2 (power can only flow from Main Dist. Bus 1 to Main Dist. Bus 2)
  iii. Non-Essential Buses
    a. Non-Ess Bus is powered by Alt 2
      - If Alt 2 fails, Alt 1 & Bat 1 can power the bus from Main Distribution Bus 2 via the interconnecting diode
    b. A/C Bus 1 & 2 are powered by Alt 1 and Bat 1
      - If Alt 1 fails, Bat 1 will power the buses
      - Alt 2 is prevented from powering the buses by the isolation diode between MC Distribution Bus 1 & 2

F. Electrical Indicating
  i. Displayed as bar graphs and text on the MFD's Engine page
    a. Engine Airframe Unit acquires the data and sends it to the Engine Indicating System for display
  ii. If the Engine page is not active, or is in backup mode, Battery 1 amp output and Ess Bus Voltage output are displayed on the left-hand edge of the display
  iii. Electrical System Annunciations
    a. Health, caution & warning messages are displayed in the Crew Alerting System (CAWs) window
      - Color coded
      - Affected parameter on the Engine page changes to the same color as the CAWs alert
    b. More info in Section 3 – Emergency Procedures & 3A – Abnormal Procedures



13. Avionics

A. Avionics will vary based on model and options

i. Operating instructions should be taken from the manuals of the respective manufacturers

14. Pitot-static, Vacuum/Pressure, and Associated Flight Instruments

A. Pitot-Static

i. Total pressure is measured on the leading edge of a pitot probe mounted on the left wing

a. Pitot probe is electrically heated to maintain proper operation in possible icing conditions

- Operated by the Pitot Heat switch
- Amber Pitot Heat caution indicates switch is On but heater is not receiving current

ii. Static pressure is measured at dual static ports mounted in the fuselage

iii. Alternate Static Source

a. Static pressure inside the cabin can be used in the event the primary source becomes blocked

- Generally due to water or ice in the pressure line

- Pressures in the cabin will vary with open heater/vents
- Reference Section 5 airspeed calibration and altitude for necessary corrections

b. Located to the right of the pilot's leg

iv. Water traps with drains are installed at Pitot and static low point to collect moisture in the system

a. Drain trap at the annual inspection and when water in the system is known or suspected

v. Instruments

a. Airspeed Indicator
- Pitot and Static Pressure

b. Altimeter
- Static Pressure

c. Rate of Climb Indicator
- Static Pressure

B. Vacuum/Pressure

i. See III.C. Generic Aircraft Systems

C. Associated Flight Instruments

i. For more details, see III.C. Generic Aircraft Systems

15. Environmental

A. Ventilation

i. Provided by ducting ram air from air inlets to eyeball outlets for each occupant

B. Cabin Heat

i. An inlet in the engine compartment ducts air over the muffler heat exchanger

a. This air is mixed with fresh ram air and ducted to the cabin occupants or the windshield

b. Muffler type heat exchanger is on the right exhaust muffler

C. Blower

i. Serials 1639 and on: An optional 3-speed blower fan may be installed to supplement ram airflow

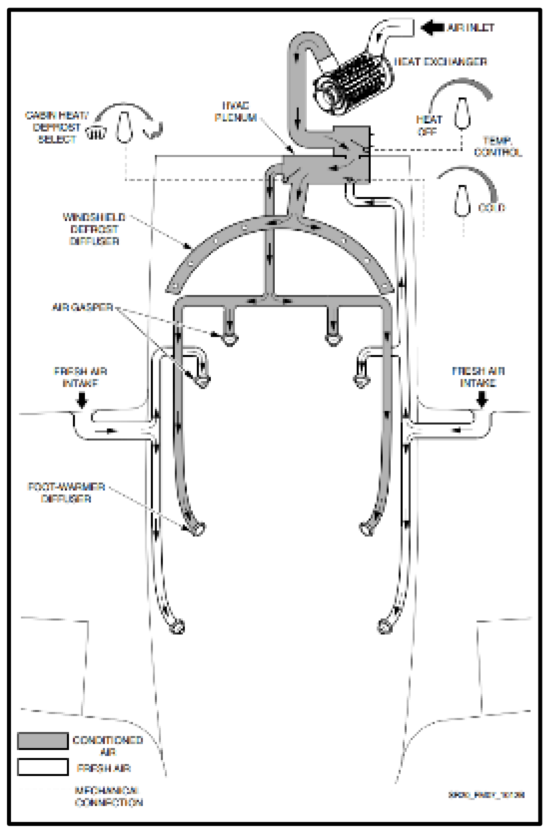
D. Specifics

i. Serials 1005 to 1638

a. System Components
- Air inlet in the upper right-hand cowl
- Heat exchanger around right exhaust muffler
- Two fresh air inlets – one in each wing root
- Air mixing plenum (behind instrument panel)
- Windshield diffuser
- Air ducting
- Air vents

b. Air Selector
- Air from the mixing plenum can be proportioned/directed to the windshield or passengers
- Rotating Full Counterclockwise = Max airflow to the windshield
- Full Clockwise = Max airflow to the passengers

c. Heat Control
- Controlled by rotating the Cabin Heat Control
- Mechanically linked to a door in a heater box
- Full Counterclockwise (Heat Off) = Bypasses heated



Serials 1005-1638 Environmental System air

- Full Clockwise = Opens door in the heater box allowing heated air into the mixing plenum

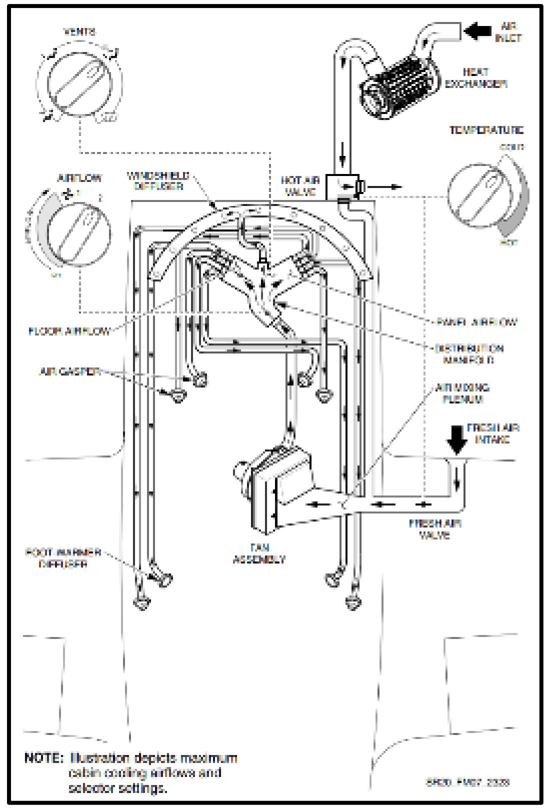
d. Cooling Control
- Controlled by rotating the Cabin Cool Control
- Full Counterclockwise = Shuts down cooling airflow to the mixing plenum
- Full Clockwise (Cold) = Allows fresh cooling air to enter the mixing plenum

ii. Serials 1639 to 1885

a. System Components
- Air inlet in the upper right-hand cowl
- Heat exchanger around right exhaust muffler
- One fresh air inlet in the right-wing root
- Air mixing chamber (under right crew seat)
- Distribution manifold (behind inst. panel)
- Windshield diffuser
- Air ducting
- Air vents

b. Air Selector
- Regulates system airflow via a mechanical linkage to a valve in the distribution manifold
- If installed, a blower fan is turned on if the selector exceeds the full open position

c. Vent Selection
- Cabin vent selector is mechanically linked to valves at the entrance to the windshield diffuser and cabin floor ducting
- Far Left: Both valves are closed – max airflow to the panel and armrest eyeball outlets
- ¼ Turn Clockwise: Opens cabin floor valve
- Another ¼ turn CW: Opens windshield diffuser valve
  - a Allows shared airflow to windshield defrost and cabin floor outlets
- Far Right: Cabin floor valve is closed providing maximum airflow to the windshield diffuser

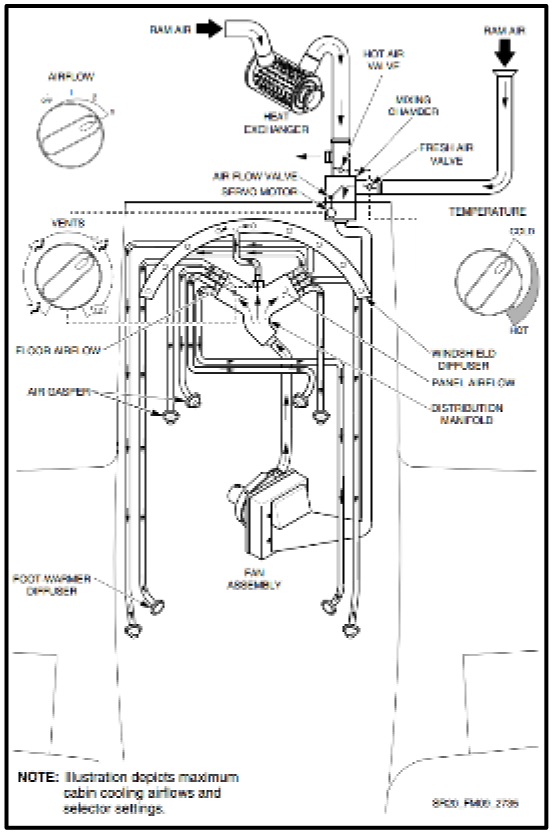


Serials 1639-1885 Environmental System

d. Temperature Selection
- Temp selector is mechanically linked to the hot air valve and fresh air intake valve
  - a Rotating the valve simultaneously opens and closes the two valves
- CW Rotation: Allows warmer air to enter
- CCW Rotation: Allows cooler air to enter

iii. Serials 1886 and Subs

a. System Components
- Air inlet in the upper right-hand cowl



Serials 1886 and subs

- Heat exchanger around right exhaust muffler
- One fresh air inlet in right lower cowl
- Air mixing chamber (on the firewall)
- Distribution manifold (behind instrument panel)
- Windshield diffuser
- Air ducting
- Air vents

b. Air Selector
- Regulates system airflow via a mechanical linkage to a valve in distribution manifold
- When the selector is moved past Off, an electromechanical linkage actuates a valve in the mixing chamber to full open
    - a Air is then distributed by ram air or optional blower fan to the distribution manifold
    - b Blower Fan: 0 = ram air, 1 = low fan, 2 = med fan, 3 = high fan

c. Vent Selection
- Cabin vent selector is mechanically linked to valves at the entrance to the windshield diffuser and cabin floor ducting
- Far Left: Both valves are closed – max airflow to the panel and armrest eyeball outlets
- ¼ Turn CW: Opens cabin floor valve
- Another ¼ turn CW: Opens windshield diffuser valve
    - a Allows shared airflow to windshield defrost and cabin floor outlets
- Far Right: Cabin floor valve is closed providing maximum airflow to the windshield diffuser

d. Temperature Selection
- Temp selector is mechanically linked to the hot air valve and fresh air intake valve
    - a Rotating the valve simultaneously opens and closes the two valves
- CW Rotation: Allows warmer air to enter
- CCW Rotation: Allows cooler air to enter

iv. Perspective & Perspective +

a. System Components
- Fresh air inlet in the lower right-hand cowling
- Heat exchanger around the right exhaust muffler
- Air mixing chamber
- Distribution manifold
- Windshield diffuser
- Air ducting
- Air vents
- Optional 3-speed blower
- Optional AC system
    - a Engine driven compressor
    - b Condenser assembly
    - c Evaporator assembly

b. Heating

- Fresh air is ducted to the heat exchanger
- Heated air is routed to the hot air valve
    - a Hot air valve controls entry of hot air into the cabin distribution system
    - b Open Valve: Heated air flows into the cabin mixing chamber
    - c Closed Valve: Heated air exits into the engine compartment and is exhausted overboard
- Cabin heat is regulated by controlling the amount of hot air in the mixing chamber
    - a Amount of hot air and fresh air is dictated by the temp selector on the instrument panel

c. Cooling

- Provided by ram air through the fresh air cowl inlet
- When the fresh air valve is open, air flows into the mixing chamber
    - a Closed = Exits into the engine compartment and is exhausted overboard
- Air Conditioning (Optional)
    - a Ram air from the fresh air intake flows into the evaporator assembly, is cooled as it passes through the evaporator coils and then is ducted to the distribution manifold
    - b Air conditioning diagram shown below, on the right

d. Air Selector

- Regulates the volume of airflow in the cabin distribution system
- When the selector is moved past the Off position, an electromechanical linkage actuates a valve in the mixing chamber to full open
    - a Air is then distributed by ram air or a blower fan (optional) to the distribution manifold

e. Vent Selection

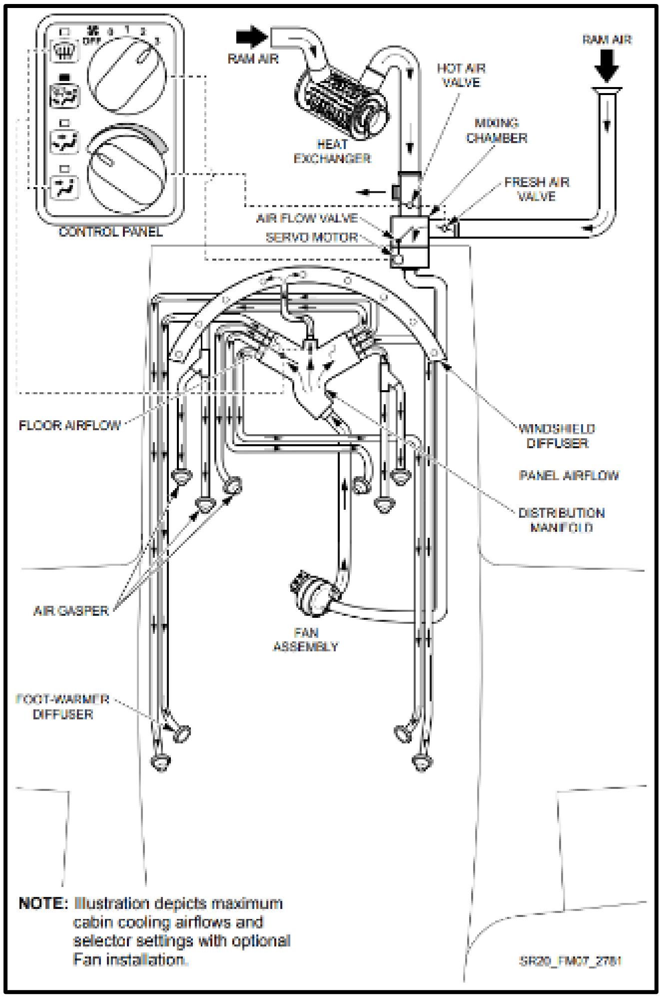
- Distribution manifold air is proportioned and directed to pax and/or the windshield with the cabin vent selector buttons
    - a Electrically actuate valves at the entrances to the windshield diffuser/cabin floor ducting
- Panel selector button: Both valves closed; max air to the panel and armrest eyeball outlets
- Panel-Foot: Opens cabin floor valve
- Panel-Foot-Windshield: Opens windshield diffuser valve; permits airflow to defrost and cabin floor outlets
- Windshield: Cabin floor valve closes; max air to windshield diffuser

f. Temp Selection

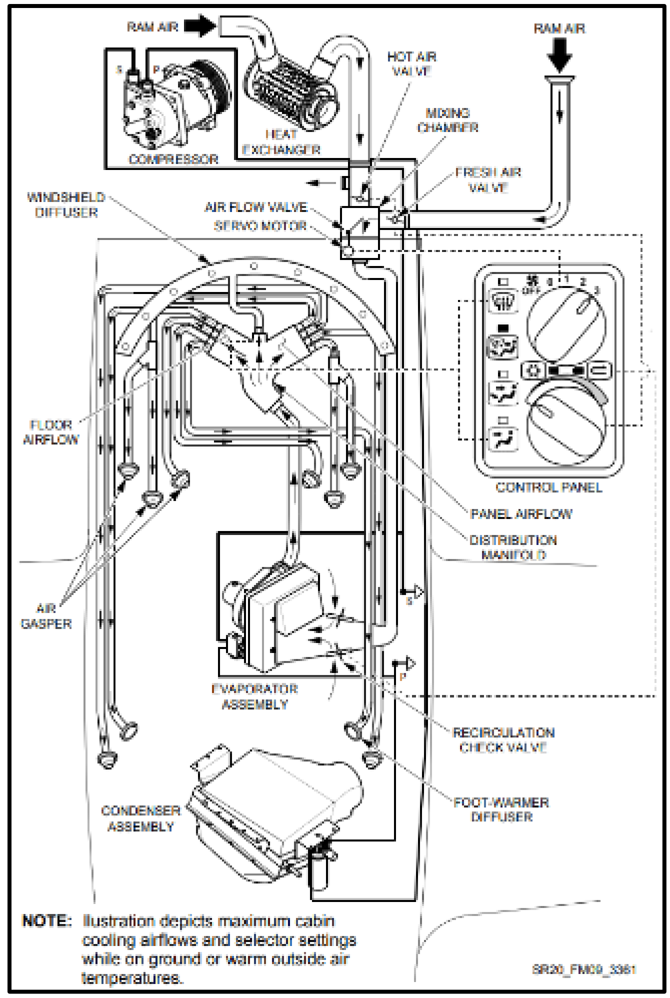
- Electrically linked to the hot and cold air valves
- Rotating the selector simultaneously opens and closes the two valves
    - a Allows hot and cold air mix and enter the distribution system
    - b Clockwise: Permits warner air to enter the system
    - c Counterclockwise: Permits cooler air into the system
- Air Conditioning (Optional)
    - a Valve on firewall closes; AC is activated
    - b Recirculation Button: Fresh air valve closes; cabin air is recirculated

g. Diagrams

- Left: Standard environmental system
- Right: Optional air conditioning system



Standard Environmental System



Optional Air Conditioning System

16. Deicing and Anti-Icing
- A. Canopy Heat
  - i. Can be used to deice the windshield (if the icing is light)
- B. Pitot Heat
  - i. Used to prevent ice buildup on the pitot/static inlets

17. Cirrus Airframe Parachute System (CAPS)
- A. Components
  - i. Parachute – 2400 sq ft round canopy
  - ii. Solid-propellant rocket
  - iii. Rocket activation handle
  - iv. Harness
- B. System Description
  - i. Composite box containing the parachute and propellant is mounted immediately aft of the baggage compartment bulkhead
  - ii. Parachute is in a deployment bag
    - a. Creates an orderly deployment process – canopy inflates only after the rocket pulls lines taut
  - iii. 3-point harness connects the fuselage to the parachute
    - a. Aft bulkhead, 2 firewall attach points
- C. Activation Handle

- i. Installed in the ceiling on the airplane centerline, just above the pilot's right shoulder
    - a. Placarded cover prevents tampering – Pull the black tab at the forward edge to remove it
- ii. Pulling the handle activates the rocket and initiates the CAPS deployment sequence
    - a. To activate the rocket:
        - Pull the T-handle from its receptacle
        - Once slack is removed (about 2"), motion stops, and greater force is required to activate
        - Clasp both hands around the T-handle and pull straight down (do a chin-up)
            - a Up to 45 pounds of force, or greater, may be required
            - b Serials 1005 to 2227
                1. Greater force required occurs as cable arms and releases the rocket igniter firing pin
                2. When the firing pin releases, two primers are discharged and ignite the rocket fuel
            - c Serials 2228 and subs
                1. The greater force required occurs as the cable arms and then releases the igniter switch plunger activating the electronic igniter

D. Deployment Characteristics
- i. Parachute is extracted outward and rearward due to rocket thrust and relative wind
    - a. In approximately 2 seconds parachute begins to inflate
- ii. As air fills the canopy, forward motion is dramatically slowed
    - a. Should be less than 3 Gs / Slight nose-up may be experienced
    - b. Nose will gradually drop until hanging nose low beneath the canopy
- iii. 8 seconds after deployment the tail will drop to its final approximately level attitude
    - a. Rear riser snub line is cut
    - b. Airplane may yaw or oscillate slightly
- iv. Descent rate is expected to be < 1700 fpm; Lateral speed = wind speed
- v. Ground impact is equivalent to touchdown from a height of 10'
- vi. Designed to work in a variety of attitudes
    - a. But deployment in an attitude other than level flight may change deployment characteristics

Conclusion:
Brief review of the main points
A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Diamond DA20

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. Fuel Pump and Primer 3. *Electrical Failure – 30 min
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

*The main systems found on the DA20. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

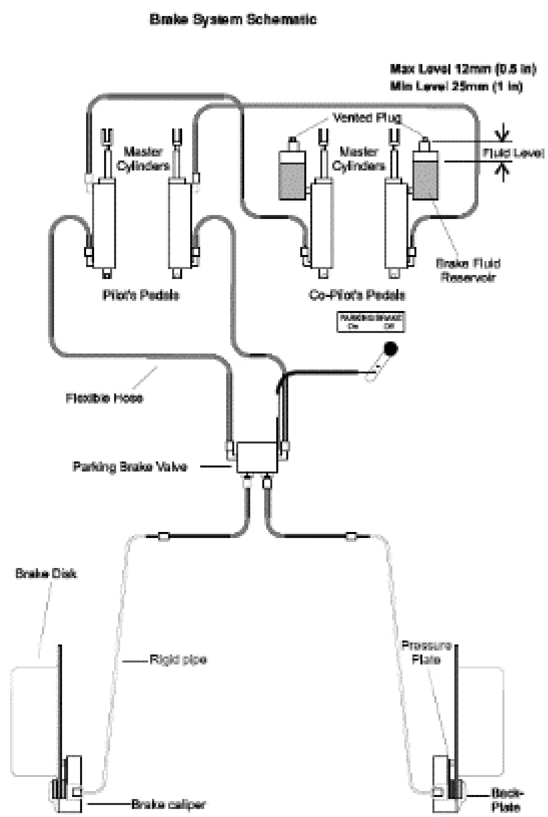
How:

*This lesson is based off the DA20 systems, and will need adjusted for your aircraft

1. **Primary Flight Controls and Trim**
   A. Ailerons - Carbon Fiber Reinforced Plastic (CFRP)
      i. Actuated via push rods
      ii. Attached with stainless steel and aluminum hinges
   B. Elevator - CFRP
      i. Actuated via push rods
      ii. Semi-Monocoque sandwich construction
      iii. Trim
         a. Controlled by a Rocker Switch
            - Switch forward = Nose Down; Switch aft = Nose Up
            - Switch controls an electrical actuator beside the vertical push rod in the vertical stabilizer
               a The actuator applies a load to compression springs on the elevator push rod
         b. Trim circuit breaker can be tripped manually to disable the system
   C. Rudder
      i. Actuated via control cables
      ii. Semi-Monocoque sandwich construction
2. **Flaps**
   A. Driven by an electric motor
      i. Electric flap actuator is protected by a circuit breaker (5 Amp)
         a. Located on the right side of the instrument panel and can be manually tripped to disable the system
   B. Controlled by 3 position flap operating switch on the instrument panel
      i. Top position – Cruise – 0º (Green Light)
      ii. Middle Position – Approach – 15º (Yellow Light)
      iii. Bottom Position – Landing – 45º (Yellow Light)
      iv. When two lights are illuminated at the same time, the flaps are in-between positions
   C. Cruise and Landing positions are equipped with position switches to prevent over-traveling

3. Powerplant and Propeller
- A. Powerplant
  - i. Continental IO-240-B Engine
    - a. Fuel Injected
    - b. 4 Cylinder
    - c. 4 Stroke
    - d. Horizontally Opposed cylinders and heads
    - e. Air cooled cylinders and heads
    - f. Propeller drive is direct from the crankshaft
    - g. 3.9 liters
    - h. 125 HP at 2800 RPM
  - ii. Engine Controls
    - a. Mixture Lever
    - b. Throttle
    - c. Alternate Air
      - Full Forward = Primary Air Intake
      - Full Aft = Alternate Air Intake
- B. Propeller
  - i. Hoffmann HO-14HM-175-157
    - a. Diameter - 5' 8.9"
    - b. Two-bladed fixed pitch propeller
    - c. Wood and glass fiber
  - ii. Sensenich W69EK7-63, 63G, or W69EK-63
    - a. Diameter – 5'9"
    - b. Two-bladed fixed pitch propeller
    - c. Wood prop

4. Landing Gear
  - i. Two main landing gear wheels (mounted to aluminum spring struts)
- B. Nose Wheel
  - i. 60° castering
  - ii. Suspension is provided by an elastomer spring
- C. Wheel Brakes
  - i. Hydraulically operated disc brakes
  - ii. Operated individually using toe-brake pedals



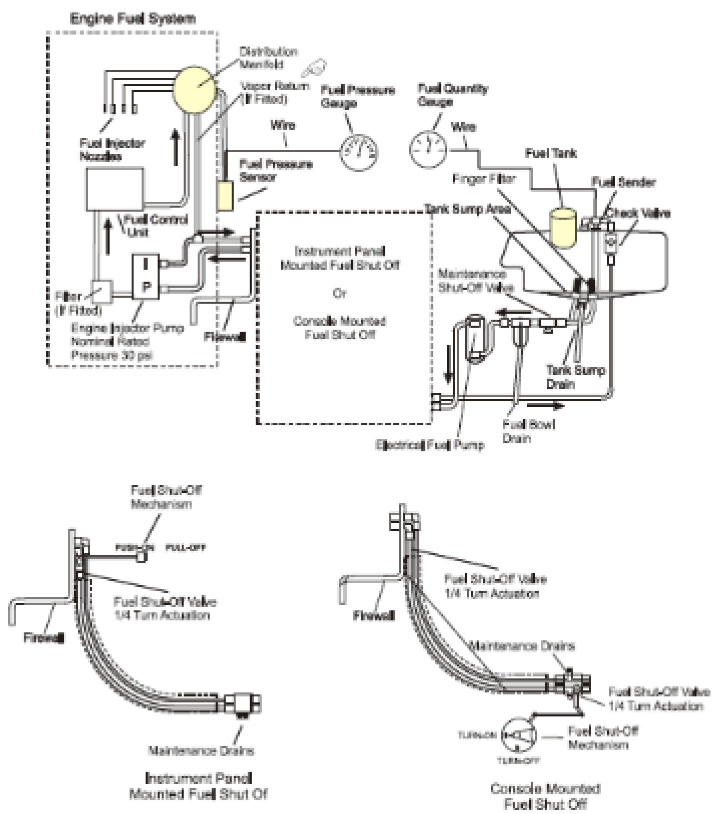
- D. Parking Brake
  - i. Repeated pushing of the toe-brake pedals will build up the required brake pressure, which will remain in effect until the brake is released

5. Fuel, Oil, and Hydraulic
- A. Fuel
  - i. Aluminum Fuel Tank
    - a. Located behind the seats, below the baggage compartment
    - b. 24.5 Gallons fuel (24 Gallons Usable)
    - c. Operation
      - Fuel is gravity fed to a filter bowl (gascolator) and then to the electric fuel pump
        - a Filter bowl must be drained before flight (black tube)
      - Electric fuel pump primes for starting (Prime ON) and is used for low throttle operations
        - a When the pump is off, fuel flows through the pump's internal bypass

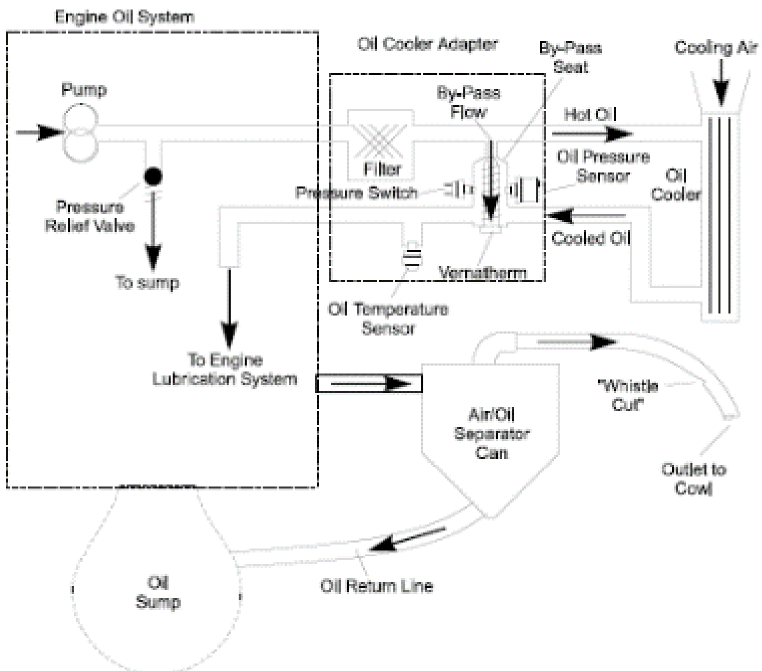
- From electric pump, fuel is delivered to the mechanical fuel pump by the fuel supply line
- Fuel is metered by the fuel control unit and flows via the fuel distribution manifold to the injector nozzles
- Return line from mechanical fuel pump's fuel vapor separator returns vapor/excess fuel to the tank

d. Electric Fuel Pump
- DUKES constant flow, vane type, two speed, electric fuel pump
  - a Fuel Prime
    1. Pump's high-speed setting, used for priming the engine prior to engine start
    2. Turning the prime pump on while running will enrich the mixture considerably
       a. At high throttle settings the effect is less noticeable
       b. At low throttle settings may cause engine roughness or engine stoppage
  - b Fuel pump
    1. Required for maintaining positive fuel pressures at low throttle settings

e. Fuel Shutoff Valve
- Closing will cause the engine to stop within a few seconds



B. Oil
   i. High pressure wet sump lubrication system
      a. Wet sump oil systems store the oil in the engine pan, dry sump systems store the oil in a separate tank
   ii. Oil is pumped by a mechanical, engine driven pump
   iii. Oil must be between 4 and 6 quarts



6. Electrical

A. Power Generation
   i. 40 Amp Generator
      a. Feeds the Main Bus via the Generator Circuit Breaker (50 Amps)
   ii. Generator Warning Light
      a. Activated by internal voltage regulator monitoring circuit - illuminates if generator fault occurs

B. Power Storage
   i. 12V battery
      a. Connects to the Master Bus via the Battery Circuit Breaker (50 Amps)

C. Power Distribution
   i. Electrical Bus

D. Consumers
   i. Individual consumers (e.g. Radio, Fuel Pump, Position Lights, etc.) are connected in series with their respective circuit breakers

E. Electrical Monitoring Instruments
   i. Voltmeter
      a. Indicates the status of the Electrical Bus
      b. Consists of a dial marked numerically from 8 – 16 volts in divisions of 2
         - Scale
            a RED for 8.0 - 11.0 volts
            b YELLOW for 11.0 - 12.5 volts
            c Green for 12.5 - 16.0 volts
            d REDLINE at 16.1 volts
   ii. Ammeter
      a. Indicates the charging (+) and discharging (-) of the battery
      b. Consists of a dial which is marked numerically from -60 to 60 amps
   iii. Generator Warning Light
      a. Illuminates during generator failure

- No output from the generator

b. The only remaining power source is the battery (20 Amps for 30 min)

7. Avionics

A. Center of the instrument panel contains the radio and navigation equipment
  i. Operating instructions should be taken from the manuals of the respective manufacturers

B. Vertical Stabilizer contains the antenna for the VHF radio equipment

C. Horizontal Stabilizer contains the antenna for the NAV equipment (VOR)

8. Pitot-static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot-Static
  i. Pitot pressure is measured on the leading edge of a calibrated probe below the left wing
    a. Airspeed indicating error, refer to Chapter 5 of POH
  ii. Static pressure is measured by the same probe
    a. Error of the static pressure system is negligible
  iii. Instruments
    a. Airspeed Indicator
      - Pitot Pressure (Ram Air Pressure) and Static Pressure
    b. Altimeter
      - Static Pressure
    c. Rate of Climb Indicator
      - Static Pressure

B. Vacuum Pressure (Gyros)
  i. Instruments
    a. Heading Indicator
    b. Attitude Indicator

C. Electrically Driven Instruments
  i. Turn Coordinator

9. Environmental

A. Cabin Heat and Defrost
  i. Directs ram air through the exhaust heat shroud into the cabin heat valve
    a. The air is directed to the window defrosting vents and to the cabin floor as selected by the lever
  ii. The cabin heat selector is used to regulate the flow of heated air

10. Deicing and Anti-Icing

A. Defrost
  i. Can be used to deice the windshield (if the icing is light)

Conclusion:
Brief review of the main points
A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Diamond DA40

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. Prop Governor fails to Low Pitch, High RPM 3. Electrical Failure – 30 min
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
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Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

The main systems found on the DA40. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

1. **Primary Flight Controls and Trim**
    A. Ailerons – Glass Fiber Reinforced Plastic (GFRP)/Carbon Fiber Reinforced Plastic (CFRP) composite sandwich
        i. Actuated via steel push rods
        ii. Attached with stainless steel and aluminum hinges
    B. Elevator – GFRP
        i. Actuated via steel push rods
        ii. Semi-Monocoque sandwich construction
        iii. Trim
            a. Electric Trim - Controlled by a Rocker Switch
                - Switch forward = Nose Down; Switch aft = Nose Up
                - Switch controls an electrical actuator beside the vertical push rod in the vertical stabilizer
                    a The actuator applies a load to compression springs on the elevator push rod
                - Trim circuit breaker can be tripped manually to disable the system
            b. Manual Trim - Controlled by a black wheel in the center of the console
                - Turn Wheel to the Front = Nose Down
                - Turn Wheel to the Rear = Nose Up
    C. Rudder – GFRP sandwich
        i. Actuated via steel control cables
        ii. Semi-Monocoque sandwich construction
2. **Flaps**
    A. GFRP/CFRP composite sandwich
    B. Driven by an electric motor
        i. Electric flap actuator is protected by a circuit breaker
            a. Can be manually tripped to disable the system
    C. Controlled by 3 position flap operating switch on the instrument panel
        i. Top position – Cruise (UP), Totally retracted, upper green light
        ii. Middle Position – Takeoff (T/O), 20°, center white light

    iii. Bottom Position – Landing (LDG), 42°, lower white light
    iv. When two lights are illuminated at the same time, the flaps are in-between positions
  D. The Up and Landing positions are equipped with position switches to prevent over-traveling

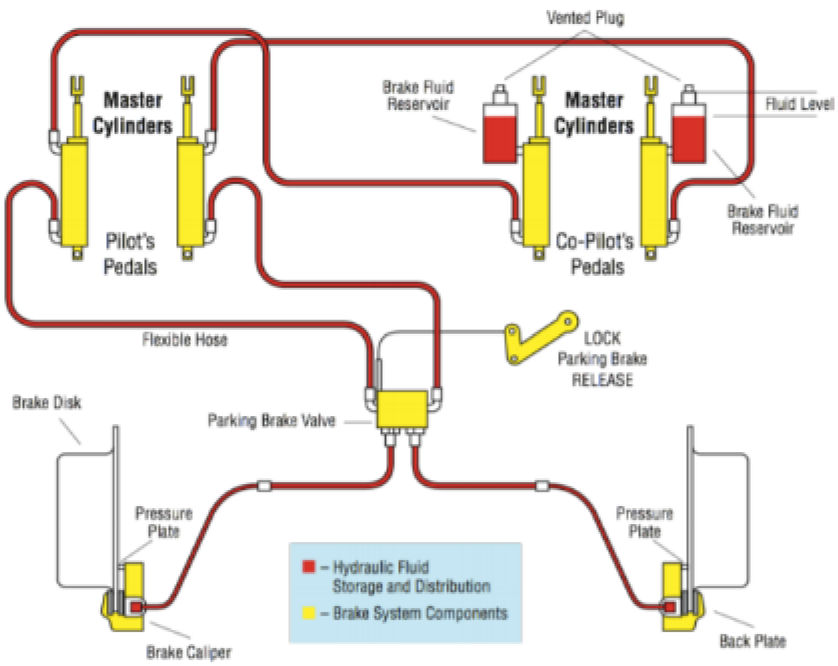
3. **Powerplant and Propeller**
  A. Powerplant
    i. Lycoming IO-360-M1A
      a. Fuel Injected
      b. 4 Cylinder
      c. 4 Stroke
      d. Horizontally Opposed cylinders and heads
      e. Air cooled cylinders and heads
      f. Propeller drive is direct from the crankshaft
      g. 180 HP at 2700 RPM (sea level and ISA)
    ii. Engine Controls
      a. Throttle
        - Left hand lever. Sets Manifold Pressure (MP).
          a High MP = large quantity of fuel-air mixture being supplied to the engine
      b. RPM Lever
        - Central lever (blue). By means of this lever, the propeller governor controls the propeller pitch and thus engine RPM (propeller RPM).
          a A selected RPM in held constant by the propeller governor independent of airspeed and throttle setting.
      c. Mixture Lever
        - Right hand lever (red). Used to set the proportions in the fuel-air mixture supplied to the engine
          a Forward (Rich) = Mixture rich in fuel
            1. At the forward stop, extra fuel is being supplied to the engine which at higher performance settings contributes to engine cooling
          b Rear (Lean) = Mixture lean in fuel
        - To shut off the engine the mixture level is pulled to the rear (lean) stop. Air without fuel is drawn into the cylinders and the engine dies
      d. Alternate Air
        - Full Forward = Primary Air Intake
        - Full Aft = Alternate Air Intake
  B. Propeller
    i. Hydraulically Regulated constant speed propeller
        - Various different models (MTV-12-B/180-17, MTV-12-B/180-17f. Different propeller options have been introduced over the years)
      b. Wood composite blades with fiber reinforced plastic coating and stainless steel edge cladding
        - Lowest weight while minimizing vibration
    ii. Governor
      a. Changes the pitch of the propeller using oil from the engine
      b. A loss of oil pressure will result in a low pitch, high rpm setting

4. **Landing Gear**
  A. Main Gear
    i. Two main landing gear wheels mounted to sprung steel struts
  B. Nose Wheel
    i. 60° castering

ii. Suspension is provided by an elastomer spring

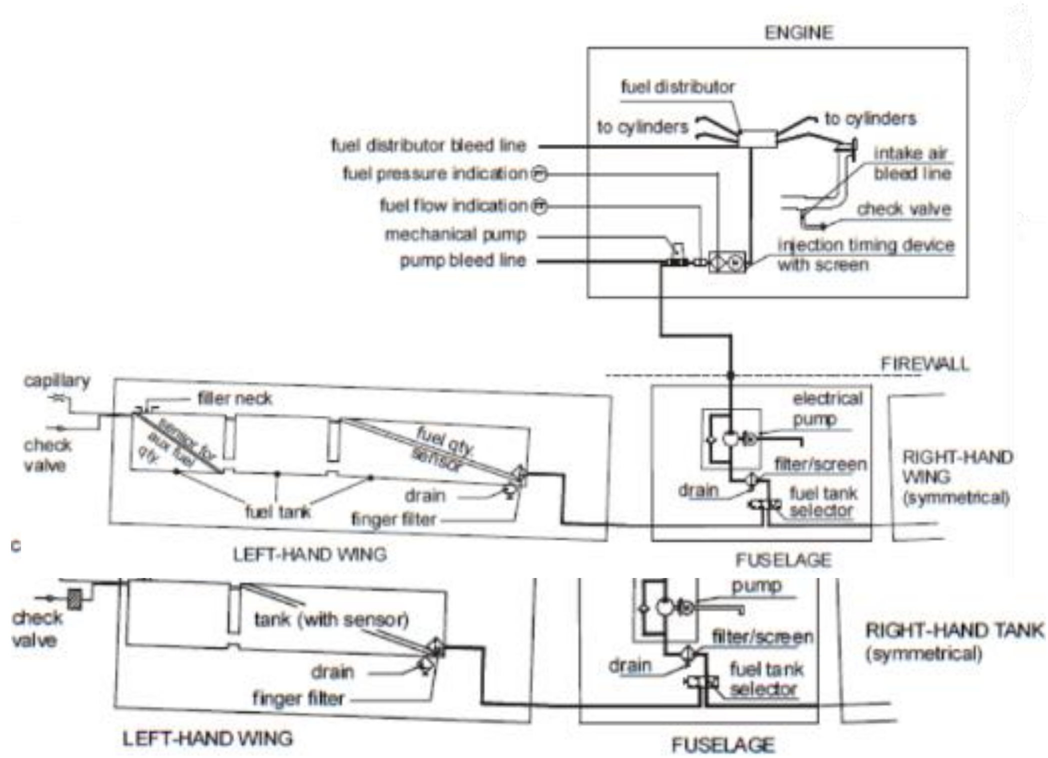
C. Wheel Brakes
   i. Hydraulically operated disc brakes
   ii. Operated individually using toe-brake pedals

D. Parking Brake
   i. Repeated pushing of the toe-brake pedals will build up the required brake pressure, which will remain in effect until the brake is released



5. Fuel, Oil, and Hydraulic

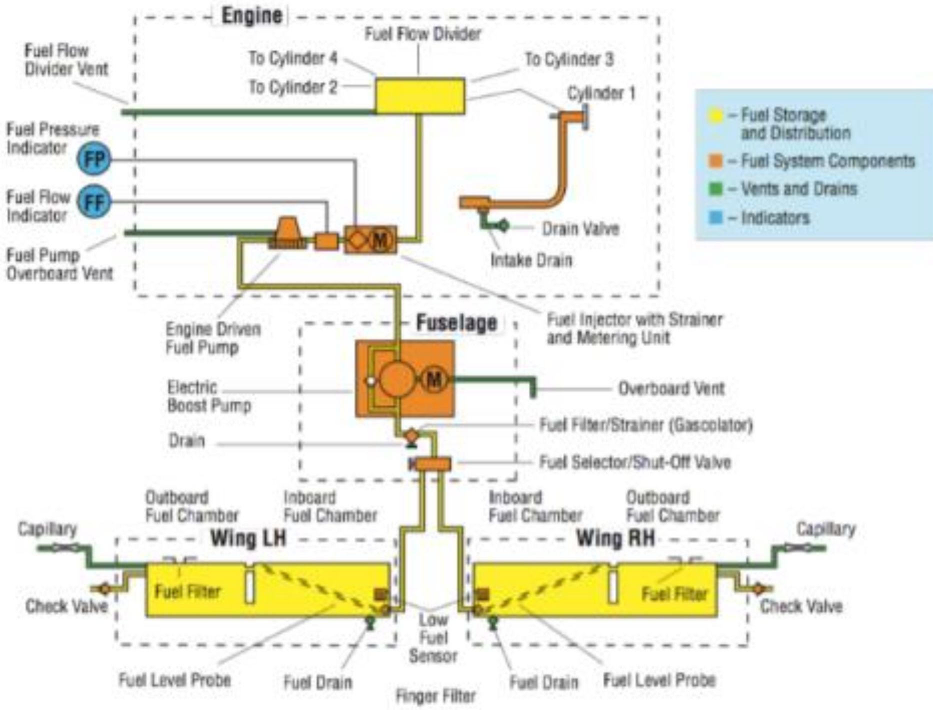
A. Fuel
   i. Tanks
      a. Aluminum Fuel Tanks
         - Standard or Long Range Tanks
            a Standard Tank – 20 Gallons per tank
               1. Two aluminum chambers in each tank
               2. Max quantity that can be indicated is 15 or 17 gallons depending on the serial number of the aircraft. At a quantity above 15 or 17 gallons, the indication remains at 15/17 gallons. The correct fuel quantity must be determined with the fuel quantity measuring device.
            b Long Range Tank – 25 Gallons per tank
               1. Three aluminum chambers in each tank
               2. *Fuel readings vary based on avionics installed
                  a. G1000 vs AUS FUEL QTY switch



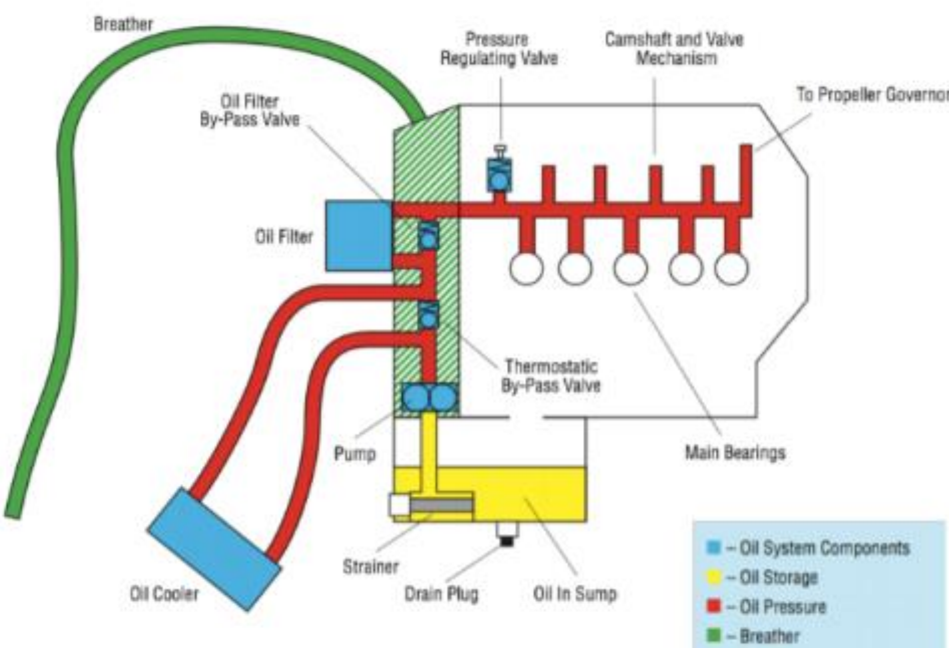
- Two vents per tank
    - a One acts as a capillary to equalize pressure and provide a safety factor in the event of a failure of the other vent
    - b Second is a check valve to allow air to enter the tank, but prevents flow to the outside

b. Fuel Pumps
- Electric and Mechanical Fuel Pump
    - a Mechanical fuel pump provides the normal supply
    - b Electric fuel pump is an auxiliary and emergency pump
        1. Does not operate under normal circumstances – used as a safety backup during takeoff, landing, and switching fuel tanks, as well as in the event of a decrease in fuel pressure

c. Fuel Tank Selector
- Left, Right, and OFF positions
    - a Off is reached by turning the selector to the right while pulling up to ensure it is not selected unintentionally

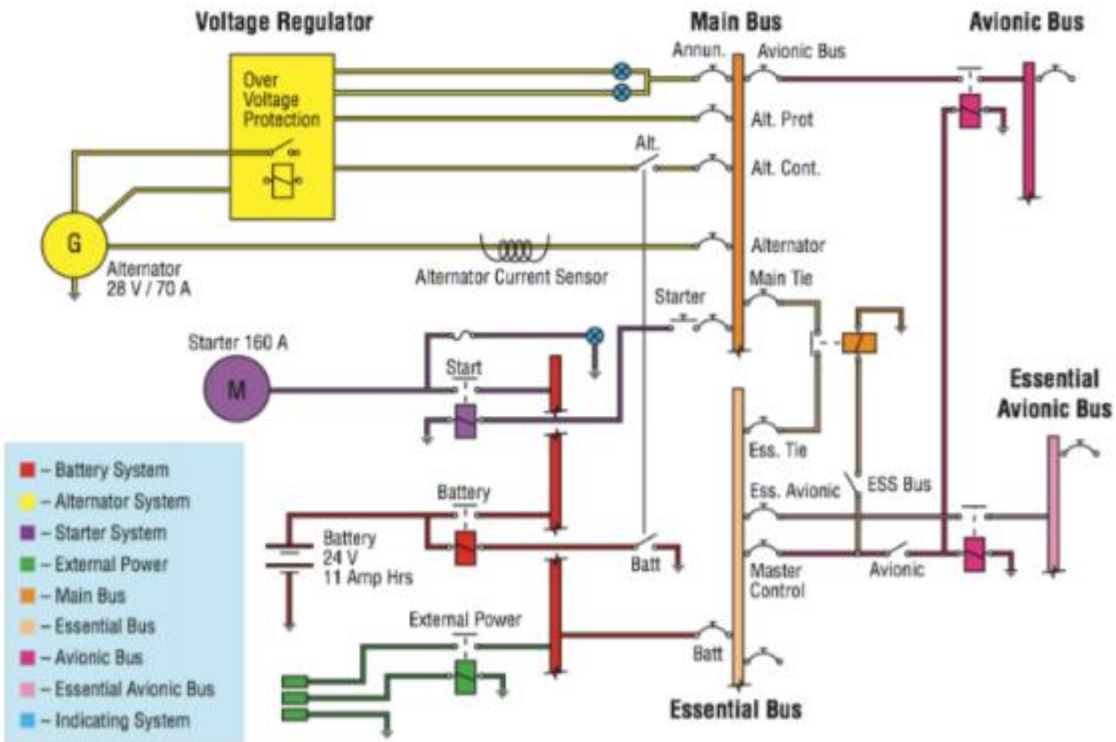


B. Oil
   i. High pressure wet sump lubrication system
      a. Wet sump oil systems store the oil in the engine pan, dry sump systems store the oil in a separate tank
   ii. Oil is pumped by a mechanical, engine driven pump
   iii. Oil must be between 4 and 8 quarts



6. Electrical

A. Power Generation
   i. 70 Amp Generator
      a. Charges the battery
      b. Driven by a V belt attached to the engine
      c. In the event of an alternator failure, the battery provides the system with electrical power
B. Power Storage
      a. Lead Acid, 10 amp-hour battery
         - Connected to the electrical system via the main CB
         - Located in the right side of the engine compartment
      b. IFR Model – Also contains a Lithium Battery Pack
         - 1 hour 30 minutes of power for the attitude gyro and flood light
         - Non-Rechargeable
C. Power Distribution
   i. Main Bus
   ii. And, if installed, the Essential Bus
      a. Following an alternator failure, the essential bus (if installed) will shed unnecessary systems and power the equipment on the essential bus for 30 minutes. After this, electrical power is available for only the artificial horizon and flood light for another 1 hour 30 minutes if the emergency power pack is installed and used
      b. The essential bus powers:
         - Nav/Com 1
         - Transponder
         - Flood Light
         - Artificial Horizon
         - VM 1000 engine instrument
         - Annunciator panel
         - GPS
         - Landing Light
         - Pitot Heat
         - Flaps
D. Consumers
   i. Individual consumers (e.g. Radio, Fuel Pump, Position Lights, etc.) are connected to the main bus/essential bus via automatic circuit breakers
E. Electrical Monitoring Instruments
   i. Voltmeter
      a. Indicates the status of the Main Bus
         - If the alternator is operating, the alternator voltage is shown, otherwise the battery voltage is shown
   ii. Ammeter
      a. Displays the current with which the alternator is being loaded
      b. Consists of a dial which is marked numerically from -60 to 60 amps
   iii. Alternator Warning Light
      a. Illuminates on alternator failure. The only source of electrical power remaining is the battery
   iv. Low Voltage Caution Light
      a. Illuminates when the voltage drops below 24 Volts



7. **Avionics**
    A. Avionics will vary based on model and options
        i. Operating instructions should be taken from the manuals of the respective manufacturers
8. **Pitot-static, Vacuum/Pressure, and Associated Flight Instruments**
    A. Pitot-Static
        i. Total pressure is measured on the leading edge of a pitot probe below the left wing
        ii. Static pressure is measured at the lower and rear edges of the pitot probe
        iii. Pitot probe is electrically heated
        iv. Alternate Static Source, if installed
            a. Static pressure inside the cabin can be used in the event of a failure of the pitot-static system
        v. Instruments
            a. Airspeed Indicator
                - Pitot Pressure (Ram Air Pressure) and Static Pressure
            b. Altimeter
                - Static Pressure
            c. Rate of Climb Indicator
                - Static Pressure
    B. Electrically Driven Instruments
        i. Directional Gyro (Main Bus)
        ii. Turn & Bank Indicator (Main Bus)
        iii. Artificial Horizon/Attitude (Essential Bus)
9. **Environmental**
    A. Cabin Heat and Defrost
        i. Directs ram air through the exhaust heat shroud into the cabin heat valve

a. The air is directed to the window defrosting vents and to the cabin floor as selected by the lever

ii. The cabin heat selector is used to regulate the flow of heated air

10. Deicing and Anti-Icing

A. Canopy Heat

i. Can be used to deice the windshield (if the icing is light)

B. Pitot Heat

i. Used to prevent ice buildup on the pitot/static inlets

Conclusion:

Brief review of the main points

A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Piper Archer II (PA-28-181)

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. 8-quart oil capacity 3. Useable fuel: 24 gallons per tank
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
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Overview

Review Objectives and Elements/Key ideas

What

The main systems found on the Piper Archer. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

1. **Primary Flight Controls and Trim**
   A. Ailerons, Horizontal Tail, and Rudder
      i. General
         a. Metal construction aircraft
            - The basic airframe is of aluminum alloy construction
            - The extremities – wing tips, cowling, tail surfaces – are of fiberglass or ABS thermoplastic
         b. Cable systems are used between the controls and control surfaces
   B. Horizontal Tail (Stabilator)
      i. What is a Stabilator?
         a. Stabilator – "All-moving tail." A fully movable aircraft stabilizer
         b. A stabilator can allow the pilot to generate a given pitching moment with lower control force
         c. Because they are easier to move, to be certified an aircraft must show an increasing resistance to increasing pilot input. To provide this resistance, stabilators on small aircraft contain an anti-servo trim tab that deflects in the same direction as the stabilator, providing an aerodynamic force resisting the pilot's input
      ii. From the POH:
         a. The horizontal tail, stabilator, is of the all-movable slab type with a trim tab mounted on the trailing edge to reduce the control system forces
         b. The stabilator provides extra stability and controllability with less size, drag and weight than conventional tail surfaces
   C. Trim
      i. Elevator Trim
         a. As mentioned above, the trim tab is mounted on the trailing edge of the stabilator
         b. The trim tab is actuated by a control wheel on the floor, between the seats
      ii. Rudder Trim
         a. Mounted on the right side of the pedestal, below the throttle quadrant
         b. Permits directional trim as needed in flight

2. **Flaps**
    A. Manually operated and spring loaded to return to the Up position
    B. A past center lock holds the flap when it is in the Up position so that it may be used as a step on the right side
        i. The flap will not support a step load except when in the full Up position. Must be completely retracted when used as a step
    C. 3 Positions – 10°, 25°, 40°
3. **Powerplant and Propeller**
    A. Powerplant
        i. Lycoming O-360 (-A4M or -A4A depending on the aircraft)
            a. 4 Cylinder
            b. 4 stroke
            c. Air cooled
            d. Direct Drive
            e. Carbureted
            f. Horizontally Opposed
            g. 180 HP at 2700 RPM
        ii. Engine Controls
            a. Throttle and Mixture Control Levers
                - Throttle adjusts RPM
                - Mixture adjusts air to fuel ratio
                - Operated via Teflon lined control cables
                - Friction Adjustment located on the right side of the control quadrant
                    a Increases or decreases friction of the throttle/mixture or can be used to lock the controls in a selected position
            b. Carburetor Heat
                - Located to the right of the control quadrant
                - ON (down) / OFF (up) settings
    B. Propeller
            a. Fixed pitch propeller
            b. One piece alloy forging
4. **Landing Gear**
        i. General
            a. Tricycle Gear
            b. Steel landing gear struts
                - Air-oil struts with a normal extension of 3.25" for the nose gear and 4.5" for the main gear
        ii. Nose Gear
            a. By using the rudder pedals and brakes, the nose gear is steerable through 30° each side of center
                - A bungee in the hose gear steering mechanism reduces steering effort and dampens bumps and shocks during taxi
                - Later aircraft have the bungee removed from the nose gear steering mechanism are only steerable through 20° each side of center
            b. Shimmy dampener is also included in the nose gear
        iii. Main Gear
            a. Main gear wheels have single disk hydraulic brake assemblies
        iv. Brake System
            a. Components
                - Dual toe brakes attached to the rudder pedals

- Hand lever
- Master cylinder

b. Operation
- The toe brakes and hand brake have their own brake cylinders, but share a reservoir
- The parking brake is incorporated in the master cylinder and is actuated by pulling back on the brake lever, depressing the knob on the left side of the handle, and releasing the brake lever
  - a To release the parking brake, pull back on the brake lever to disengage the catch mechanism and allow the handle to swing forward

5. Fuel, Oil, and Hydraulic

A. Fuel

i. Tanks

a. 2 tanks. 24 gallons useable fuel in each, 25 gallons total

b. Each tank is equipped with a filler neck indicator tab to aid in determining fuel remaining when the tanks are not full
- Usable capacity to the bottom of the indicator is 17 gallons

ii. Fuel Pumps

a. Two fuel pumps – An engine driven pump and an auxiliary electric fuel pump
- Aux electric pump is provided in case of failure of the engine driven pump and should be used for all takeoffs and landings, and when switching tanks

iii. Operation

a. Main tanks→Fuel Selector→Electric Fuel Pump→Engine Fuel Pump→Carburetor

iv. Fuel Selector

a. Selections: Left Tank, Right Tank, OFF
- The button on the fuel selector must be depressed and held to select OFF

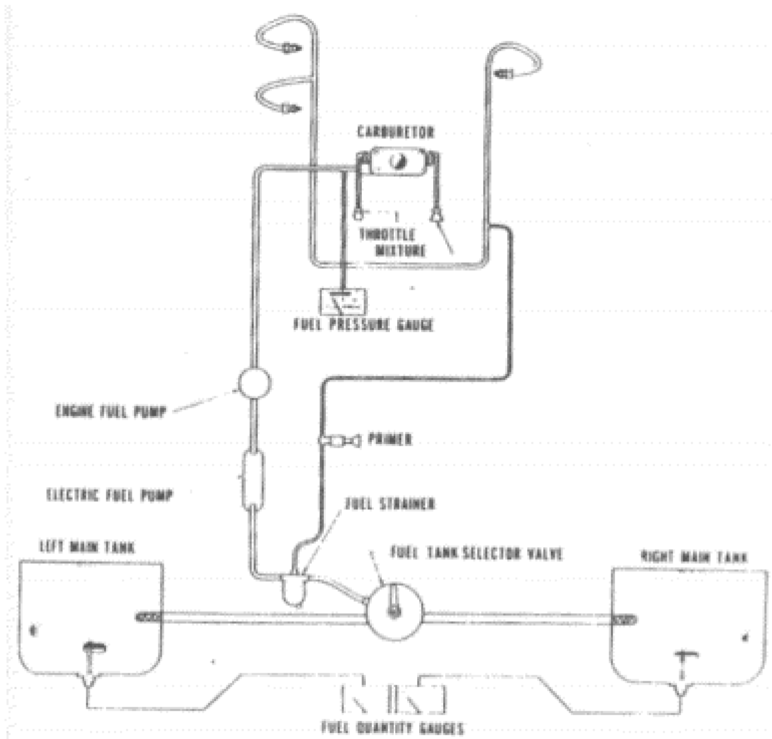
v. Engine Priming

a. Facilitates starting
- Can see Primer line in the fuel system schematic below

b. From Section 4, Starting Engine when Cold - If engine does not start within 10 seconds, prime the engine and repeat

vi. Indications

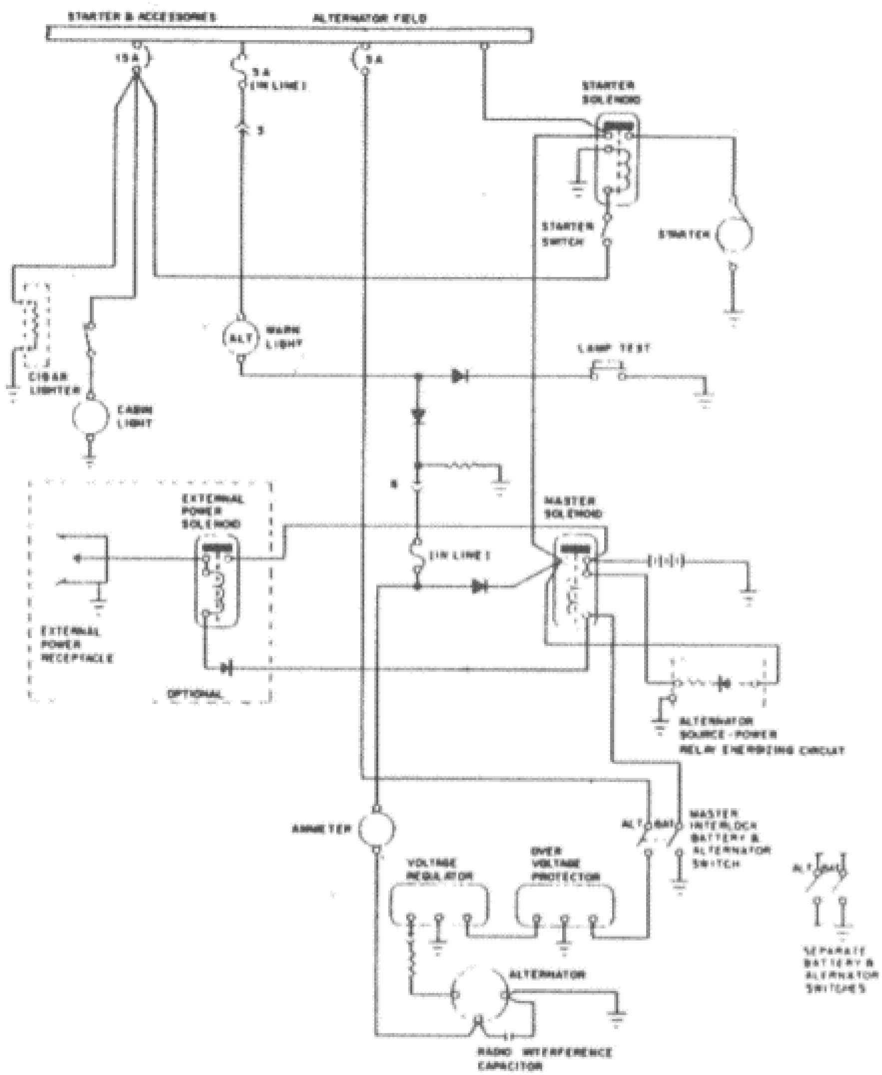
a. Quantity and pressure are indicated in gauges located in a cluster on the left side of the instrument panel



B. Oil
   i. Wet sump oil system
      a. Oil is drawn from the sump to the oil cooler, then to the pressure relief valve, and on to the engine and then by gravity back to the sump
         - Oil Cooler – in the even that cold oil or an obstruction restricts flow to the cooler, and oil cooler bypass is provided
         - Oil Pressure Relief Valve – regulates the engine oil pressure by allowing excess oil to return to the sump
   ii. Capacity: 8 quarts
C. Hydraulic
   i. The engine has no hydraulic system. See Brake System above for aircraft hydraulics

6. Electrical

A. General
   i. 14 volt, 60 amp alternator
   ii. 12 volt battery
      a. Mounted in a plastic box immediately aft of the baggage compartment
   iii. Additional Components: voltage regulator, overvoltage relay, and master switch relay
      a. Regulator and overvoltage relay are located on the forward left side of the fuselage behind the instrument panel



B. Emergency Bus
   i. An optional Radio Master switch can be installed to control power to the radios
   ii. An emergency bus switch is also installed to provide auxiliary power to the avionics bus in event of a radio master switch circuit failure
   iii. Emergency Bus Switch is located behind the lower right shin guard, to left of the circuit breaker panel

C. Consumers
   i. Standard accessories include: starter, electric fuel pump, stall warning indicator, cigar lighter, fuel gauge, ammeter, and annunciator panel
   ii. Optional accessories include: navigation lights, wing recognition lights, anti-collision light, landing light, instrument lighting, and cabin dome light
   iii. Circuits will handle the addition of communication and navigation equipment

D. Electrical Monitoring Instruments
   i. Ammeter
      a. The ammeter displays the load placed on the alternator (it does not indicate battery discharge)
         - With all electrical equipment off the ammeter will be indicating the amount of charging current demanded by the battery
         - As each electrical item is turned on, the current will increase to a total appearing on the ammeter

(this total includes the battery)

- The average continuous load for night flight, with radios on, is about 30 amperes. The 3 ampere value, plus approximately 2 amperes for a fully charged battery will appear continuously under these flight conditions

b. The amount of current shown on the ammeter will tell immediately if the alternator system is operating normally, as the amount of current shown should equal the total amperage drawn by the equipment operating

ii. Annunciator Panel

a. Includes various indications provided as a warning to the pilot that a system may not be operating properly, and the pilot should check and monitor the applicable system to determine if or when any necessary action is required (i.e. alternator indicator light)

7. Avionics

A. Avionics will vary based on model and options

i. Operating instructions should be taken from the manuals of the respective manufacturers

B. Radios are located on the upper right panel

i. Circuits are available for addition of optional radio equipment

8. Pitot-static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot-Static

i. Supplies pitot and static pressure for the airspeed indicator, altimeter, and vertical speed indicator

ii. Components

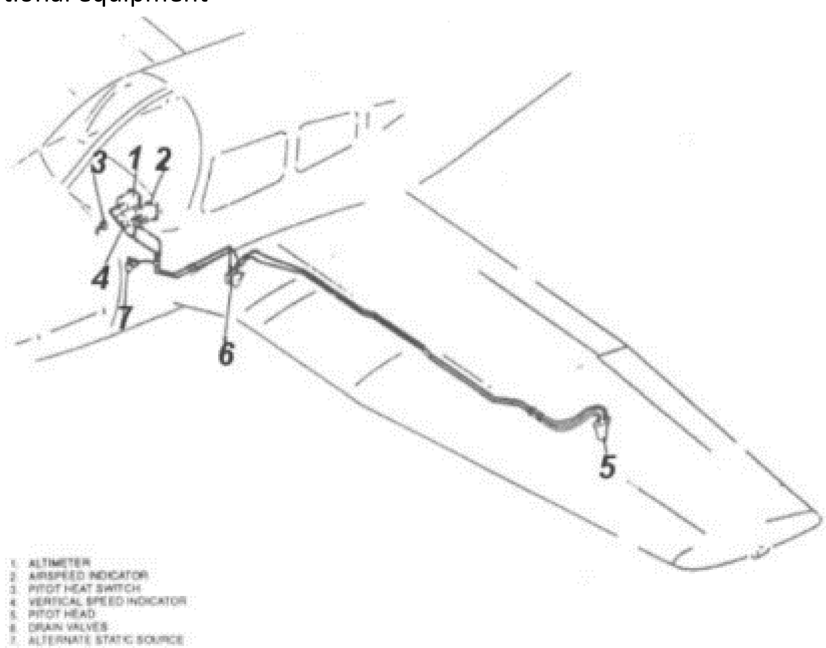
a. Pitot head – picks up pitot and static pressures

b. Pitot and Static lines – carry pitot and static pressures through the wing and fuselage to the gauges on the instrument panel

c. Alternate Static Source – If installed, allows the pilot to select an alternate static source from inside the aircraft for the altimeter, vertical speed indicator, and airspeed indicator

- The storm window and cabin vents must be closed
- The cabin heater and defroster must be on
- The altimeter error is less than 50' unless otherwise placarded

iii. Pitot Heat – optional equipment



B. Vacuum Pressure (Gyros)
   i. Designed to operate the air driven gyro instruments – directional gyro and attitude indicator
   ii. Components - Engine driven vacuum pump, Vacuum regulator, Filter, and the necessary plumbing
   iii. Vacuum Gauge
      a. A decrease in pressure (low vacuum indicator light) that remains constant over an extended period may indicate a dirty filter, dirty screens, a sticking vacuum regulator or a leak in the system
      b. Zero pressure indicates a sheared pump drive, defective pump, a defective gauge, or a collapsed line
   iv. Vacuum Regulator
      a. Protects the gyros
      b. The valve is set so normal operation reads 5.0 ± .1 inches of mercury
         - Higher settings will damage the gyros, lower settings will result in unreliable indications

C. Electrically Driven Instruments
   i. Turn and Bank indicator
   ii. As necessary, other installed electrical equipment

9. Environmental

A. Cabin Heat and Defrost
   i. Heat for the cabin and defrost is provided by a heater muff attached to the exhaust system
      a. The amount of heat can be regulated with the controls on the far right of the instrument panel

B. Fresh Air Inlets
   i. Located on the leading edge of the wing
      a. Adjustable outlet is located on the side of the cabin near the floor of each seat, as well as overhead (if installed)

C. Air Conditioning (if installed)
   i. Recirculating air system
   ii. Consists of: Evaporator, scoop, condenser, compressor, blower, switches, and temperature controls
   iii. Controls are located on the lower right side of the instrument panel
      a. Temp Control, Fan Speed, On/OFF
   iv. Whenever the throttle is in the full forward position, it actuates a micro switch which disengages the compressor and retracts the scoop to obtain maximum power and rate of climb
      a. When the throttle is retarded approximately ¼", the system will turn back on

10. Deicing and Anti-Icing

A. Defrost
   i. Can be used to deice the windshield (if the icing is light)

B. Pitot Heat (if installed)
   i. Helps to alleviate problems with icing and heavy rain

Conclusion:

Brief review of the main points

A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Piper Archer III (PA-28-181)

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. 8-quart oil capacity 3. Useable fuel: 24 gallons per tank
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the operation of the aircraft systems.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The inner workings of the airplane; to develop a better understanding of what is what, and what is where.

Overview

Review Objectives and Elements/Key ideas

What

The main systems found on the Piper Archer. This includes the primary flight controls and trim, flaps, powerplant, propeller, landing gear, fuel, oil and hydraulic systems, electrical and avionics systems, flight instruments and the environmental system.

Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

1. **Primary Flight Controls and Trim**
   - A. Ailerons, Horizontal Tail, and Rudder
     - i. General
       - a. Metal construction aircraft
         - The basic airframe is of aluminum alloy construction
         - The extremities – wing tips, cowling, tail surfaces – are of fiberglass or ABS thermoplastic
       - b. Cable systems are used between the controls and control surfaces
   - B. Horizontal Tail (Stabilator)
     - i. What is a Stabilator?
       - a. Stabilator – "All-moving tail." A fully movable aircraft stabilizer
       - b. A stabilator can allow the pilot to generate a given pitching moment with lower control force
       - c. Because they are easier to move, to be certified, an aircraft must show an increasing resistance to increasing pilot input
         - To provide this resistance, stabilators contain an anti-servo trim tab that deflects in the same direction as the stabilator, providing an aerodynamic force resisting the pilot's input
     - ii. Horizontal tail, stabilator, is of the all-movable slab type with a trim tab mounted on the trailing edge to reduce the control system forces
       - a. Stabilator provides extra stability and controllability with less size, drag and weight than conventional tail surfaces
   - C. Trim
     - i. Elevator Trim
       - a. As mentioned above, the trim tab is mounted on the trailing edge of the stabilator
       - b. The trim tab is actuated by a control wheel on the floor, between the seats
     - ii. Rudder Trim
       - a. Mounted on the right side of the pedestal, below the throttle quadrant
       - b. Permits directional trim as needed in flight
2. **Flaps**

A. Manually operated and spring loaded to return to the Up position
B. A past center lock holds the flap in the Up position so it may be used as a step on the right side
    i. Flap must be completely retracted when used as a step
C. 3 Positions: 10º, 25º, 40º

3. Powerplant and Propeller

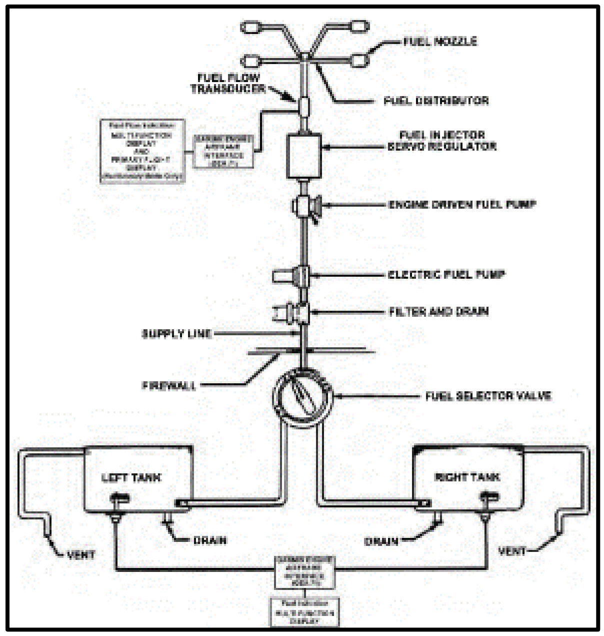
A. Powerplant
    i. Lycoming IO-360-B4A
        a. 4 Cylinder
        b. Direct drive
        c. Air-cooled
        d. Fuel injected
        e. Horizontally opposed
        f. 180 HP at 2700 RPM
    ii. Engine Controls
        a. Throttle and Mixture Control Levers
            - Throttle adjusts RPM
            - Mixture adjusts air to fuel ratio
            - Operated via Teflon lined control cables
            - Friction Adjustment located on the right side of the control quadrant
                a Increases or decreases friction of the throttle/mixture or can be used to lock the controls in a selected position
B. Propeller
        a. Sensenich 76" diameter fixed pitch propeller
        b. One piece alloy forging

4. Landing Gear

    i. General
        a. Tricycle Gear
        b. Landing gear struts
            - Air-oil struts with a normal extension of 3.25" for the nose gear and 4.5" for the main gear
    ii. Nose Gear
        a. Using the rudder pedals and brakes, the nose gear is steerable through 20º each side of center
        b. Shimmy dampener is also included in the nose gear
    iii. Main Gear
        a. Main gear wheels have single disk hydraulic brake assemblies
    iv. Brake System
        a. Components
            - Dual toe brakes attached to the rudder pedals
            - Hand lever
            - Master cylinder
            - Reservoir
        b. Operation
            - The toe brakes and hand brake have their own brake cylinders, but share a reservoir
            - The parking brake is incorporated in the hand lever master cylinder and is actuated by pulling back on the brake lever, depressing the knob on the left side of the handle, and releasing the brake lever
                a To release, pull back on lever (disengages catch mechanism) and allow the handle to swing forward

5. Fuel, Oil, and Hydraulic

- A. Fuel
  - i. Tanks
    - a. 2 tanks. 24 gallons useable fuel in each, 25 gallons total
    - b. Each tank is equipped with a filler neck indicator tab to determine fuel status
      - Usable capacity to the bottom of the indicator is 17 gallons
  - ii. Fuel Pumps
    - a. Two fuel pumps – An engine driven pump and an auxiliary electric fuel pump
      - Aux electric pump is provided in case of failure of the engine driven pump and should be used for all takeoffs and landings, and when switching tanks
  - iii. Operation
    - a. See diagram
    - b. Main tanks→Fuel Selector→Electric Fuel Pump→Engine Fuel Pump→Fuel Injector
    - c. Fuel Injection – Avstar RSA-5AD1 Injector



      - Based on principal of differential pressure – balances air pressure vs fuel pressure
      - Servo valve establishes fuel pressure
        - a Meters fuel flow proportionally with airflow and maintains mixture as set
        - b Fuel flow divider receives and distributes fuel to each cylinder
  - iv. Fuel Selector
    - a. Selections: L, R, OFF
      - Button on the fuel selector must be depressed and held to select OFF
  - v. Indications
    - a. Displayed on G1000
    - b. After power-up, fuel on board should be synchronized with fuel sensed in each tank
      - FOB SYNC on MFD AUX-WEIGHT Planning page
      - Necessary for accurate calculations (range, endurance, range ring, etc.)
- B. Oil
  - i. Wet sump oil system
    - a. Oil is stored in a sump that is part of the engine (usually at the bottom of the engine casing)
  - ii. Capacity: 8 quarts
  - iii. General Operation (POH doesn't describe specific operation)
    - a. Oil is drawn from the sump to an oil cooler, to a pressure relief valve, to the engine, and then by gravity back to the sump
      - Oil Cooler – Bypassed if oil is cold or an obstruction restricts flow to the cooler
      - Oil Pressure Relief Valve – regulates oil pressure by allowing excess oil to return to the sump
- C. Hydraulic
  - i. See Brake System above for aircraft hydraulics

6. Electrical

- A. Power Generation
  - i. 28-volt, 70-amp alternator
- B. Power Storage
  - i. 24-volt primary battery

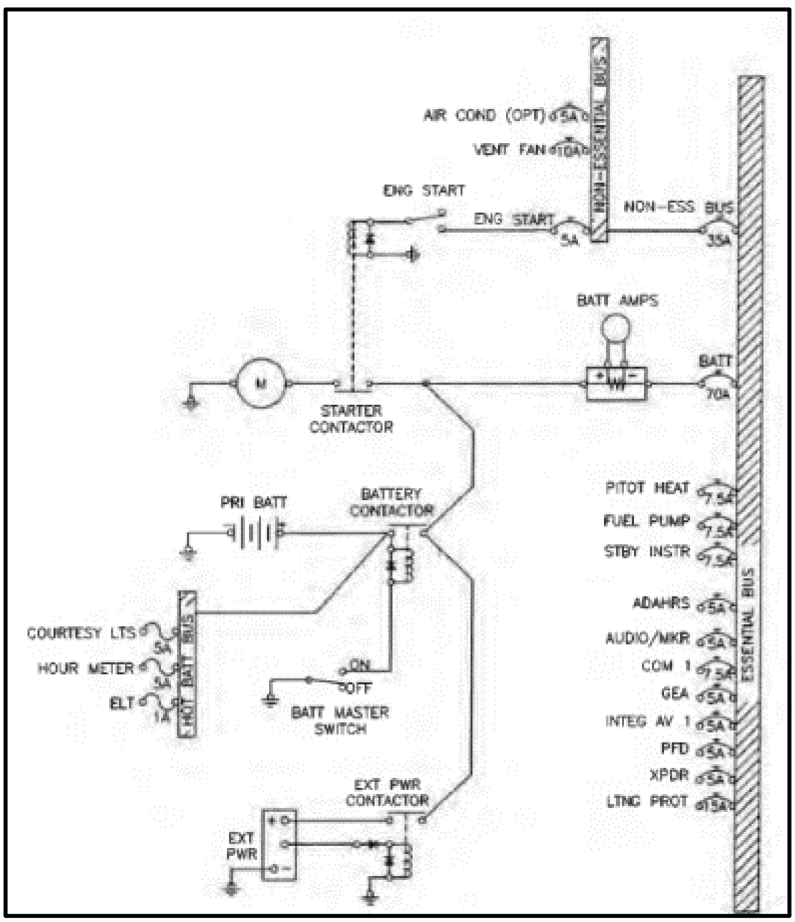
a. Mounted on a shelf in the aft fuselage
b. Provides power for engine starting and when the engine is not running
c. Battery master switch: Powers starter, essential bus, non-essential bus, and lighting bus

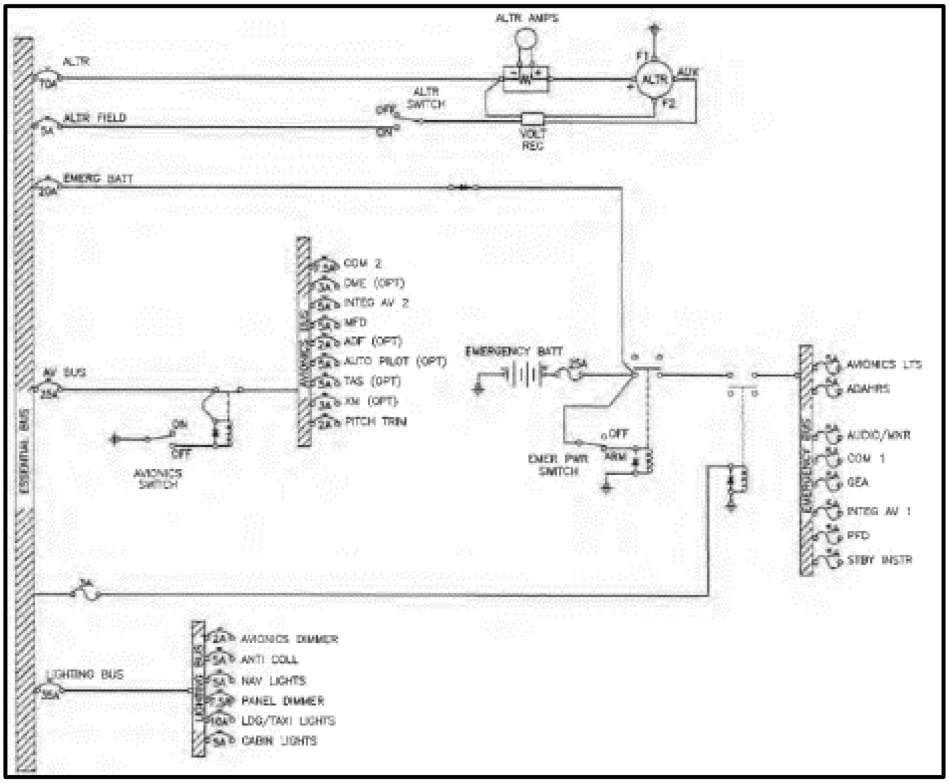
ii. 24-volt emergency battery
a. Mounted on a shelf in the aft fuselage, just forward of the primary battery
b. Provides power to the Emergency Bus in the case of a complete electrical failure
- Powers standby instruments, PFD functions (nav/com 1) and the audio panel
- Minimum of 30-minute duration (if voltage is greater than 23.3 volts prior to flight)

c. With Emerg Batt switch in Arm, power is automatically applied to emergency bus if power is lost
d. Isolated from emergency bus equipment via a relay controlled by Emerg Batt switch
- Diode allows the battery to be charged but prevents discharge when alternator is off

C. Distribution
i. Various electrical buses
a. Hot Battery Bus
b. Lighting Bus
c. Essential Bus
d. Non-Essential Bus
e. Avionics Bus

ii. Circuit breaker panel is located on the lower right side of the instrument panel





D. Voltage Regulator
   i. Regulate bus voltage to 28 volts & removes alternator if it exceeds 32 volts (preventing damage)
      a. ALTR Fail warning CAS message

E. Electrical Monitoring Instruments
   i. Alternator Amps
      a. Displays the load placed on the alternator
         - With all electrical equipment off the ammeter will be indicating the amount of charging current demanded by the battery
         - As each electrical item is turned on, the current will increase to a total appearing on the ammeter (this total includes the battery)
   ii. System Volts
   iii. Battery Amps
   iv. Crew Alerting System (CAS)
      a. Various indications provided as a warning that a system may not be operating properly
         - Check/monitor the applicable system to determine if or when action is required
      b. Master Warning & Caution on lower right side of PFD
         - CAS text messages appear in lower right area of the PFD (i.e., ALTR FAIL warning)
         - Severity is categorized as: Warning, Caution, Advisory

7. Avionics

A. Avionics will vary based on model and options
   i. Operating instructions should be taken from the manuals of the respective manufacturers

8. Pitot-static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot-Static
   i. Supplies pitot and static pressure for the airspeed indicator, altimeter, and vertical speed indicator

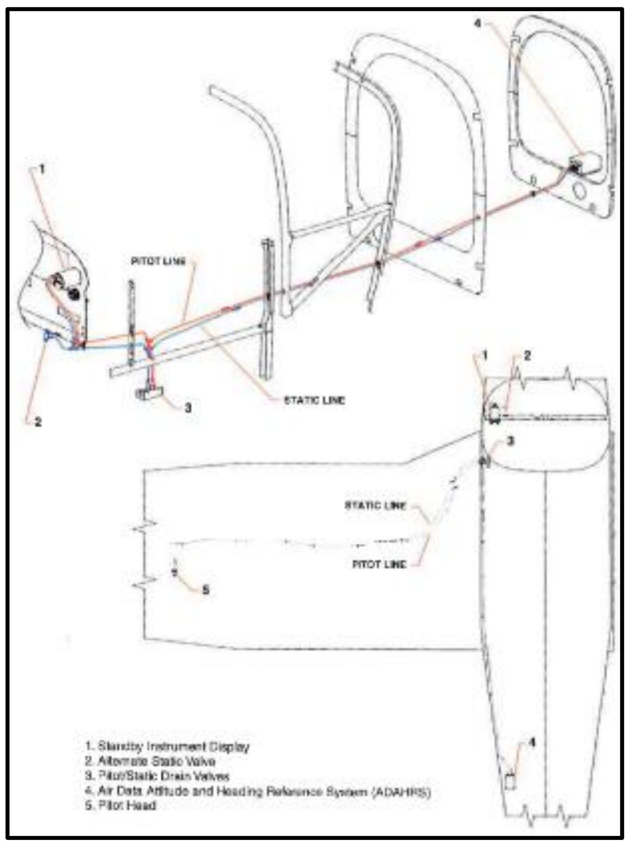
- ii. Components
  - a. Pitot head – Pitot & static pressures
    - Bottom of left wing
  - b. Pitot and Static lines – carry pitot and static pressures through the wing and fuselage to Garmin Air Data Computer and standby instrument
  - c. Alternate Static Source – Alternate static source from inside the aircraft for the altimeter, vertical speed indicator, and airspeed indicator
    - The storm window and cabin vents must be closed
    - The cabin heater and defroster must be on
    - The altimeter error is less than 50’ unless otherwise placarded
- iii. Pitot Heat
  - a. Alleviates problems with icing/heavy rain

B. Air Data Computer (ADC)

- i. EFDs utilize the same instrument inputs as traditional gauges (pitot/static inputs), however the processing is different
- ii. The pitot static inputs are received by an ADC
  - a. The ADC computes the difference between the total pressure and the static pressure and generates the information necessary to display the airspeed on the PFD
  - b. Altitude information is derived from the static port just as an analogue system does; however, the static pressure does not enter a diaphragm
    - The ADC computes the received barometric pressure and sends a digital signal to the PFD (primary flight display) to display the proper altitude

C. AHRS

- i. Electronic flight displays have replaced free-spinning gyros with sold-state laser systems that are capable of flight at any attitude without tumbling
- ii. The AHRS sends attitude information to the PFD to generate the pitch and bank information of the attitude indicator
- iii. Heading information is derived from a magnetometer that senses the earth’s lines of magnetic flux
- iv. All of the information is processed and then sent to the PFD to be displayed



9. Environmental

A. Cabin Heat and Defrost

- i. Heat for the cabin and defrost is provided by a heater muff attached to the exhaust system
  - a. Amount of heat can be regulated with the controls on the far right of the instrument panel

B. Fresh Air Inlets

- i. Located on the inboard portion of the leading edge of the wing

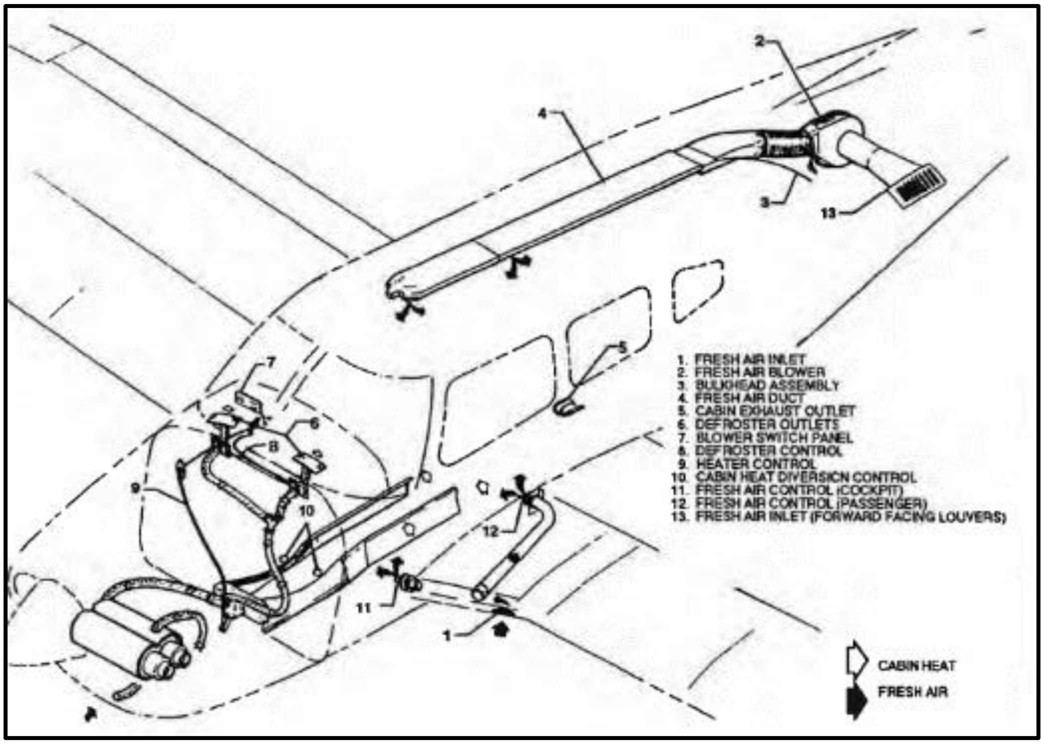
a. Adjustable outlets are on the side of the cabin near the floor and overhead at each seat

ii. Air is exhausted through an outlet in the rear seat

C. Cabin Air Blower (optional)

i. Optional overhead ventilating system with a cabin air blower is available on models w/o AC

ii. 3 positions: Off, Low, High



D. Air Conditioning (if installed)

i. Recirculating air system

ii. Consists of: Evaporator, condenser, compressor, blower, switches, and temperature controls

a. Evaporator (behind left rear of baggage compt.) cools the air

b. Condenser is mounted on a retractable scoop (bottom of the fuselage, rear of baggage area)

iii. Blower pulls air from baggage area through evaporator and then is distributed to passenger outlets

iv. Switches are left of throttle quadrant & temp control is on right side of instrument panel

a. Switches: Fan speed, AC On/Off

v. Whenever the throttle is in the full forward position, it actuates a micro switch which disengages the compressor and retracts the condenser door to obtain maximum power and rate of climb

a. Fan continues to operate – air will remain cool for about 1 minute

b. When the throttle is retarded about ¼", the condenser door extends and the system turns back

10. Deicing and Anti-Icing

A. Defrost

i. Can be used to deice the windshield (if the icing is light)

B. Pitot Heat

i. Helps to alleviate problems with icing and heavy rain

Conclusion:

Brief review of the main points

A thorough understanding of the airplane's systems makes a safer, smarter pilot.

II.E. Piper Arrow (PA-28R-201)

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The student should develop knowledge of the elements related to the aircraft systems and their operation as required in the ACS/PTS.
Key Elements	1. Powerplant 2. 8-quart oil capacity 3. Useable Fuel: 36 gallons per tank
Elements	1. Primary Flight Controls and Trim 2. Flaps 3. Powerplant and Propeller 4. Landing Gear 5. Fuel, Oil, and Hydraulic 6. Electrical 7. Avionics 8. Pitot Static, Vacuum Pressure, and Associated Flight Instruments 9. Environmental 10. Deicing and Anti-Icing
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Why

Understanding how the airplane works internally will allow for better troubleshooting and problem identification. The pilot will have a better understanding of the airplane as a whole.

How:

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         b. From the POH:
            - The horizontal tail, stabilator, is of the all-movable slab type with a trim tab mounted on the trailing edge to reduce the control system forces
            - The stabilator provides extra stability and controllability with less size, drag and weight than conventional tail surfaces
      iii. Rudder
         a. Conventional rudder with rudder trim
   B. Trim
      i. Elevator Trim
         a. As mentioned above, the trim tab is mounted on the trailing edge of the stabilator
         b. The trim tab is actuated by a control wheel on the floor, between the seats
      ii. Rudder Trim
         a. Permits directional trim as needed in flight

b. Control is mounted on the right side of the pedestal, below the throttle quadrant

2. Flaps

A. Manually operated and spring loaded to return to the Up position

B. A past center lock holds the flap when it is in the Up position so that it may be used as a step on the right side

i. The flap will not support a step load except when in the full Up position. Must be completely retracted when used as a step

C. 3 Positions – 10°, 25°, 40°

i. The aircraft will experience a pitch change during flap extension and retraction

a. This can be corrected either by stabilator trim or increased control wheel pressure

3. Powerplant and Propeller

A. Powerplant

i. Lycoming IO-360-C1C6

a. 4 Cylinder
b. 4 stroke
c. Air cooled
d. Direct Drive
e. Fuel Injected
f. Horizontally Opposed
g. 200 HP at 2700 RPM

ii. Engine Controls (Throttle, Prop, Mixture)

a. Throttle Lever - Adjusts manifold pressure
- Incorporates a gear up warning horn which is active during the last portion of travel of the throttle lever to the low power position. The horn will sound until the gear is down and locked or power is increased

b. Propeller Control Lever – Adjusts propeller speed from high rpm to low rpm

c. Mixture Control Lever - Adjusts air to fuel ratio

d. General
- Throttle, propeller, mixture are operated via Teflon lined control cables
- Friction Adjustment located on the right side of the control quadrant
  a Increases or decreases friction of the levers

e. Alternate Air Control
- In the up/closed position, the engine is operating on filtered air
- In the down/open position, the engine is operating on unfiltered, heated air

B. Propeller

a. 2 blade, McCauley 90DHA-16
b. Constant speed, controllable pitch propeller
c. 74" diameter

4. Landing Gear

i. General

a. Retractable tricycle landing gear
- Hydraulically actuated by an electrically powered pump
- Approximately 7 seconds retraction/extension

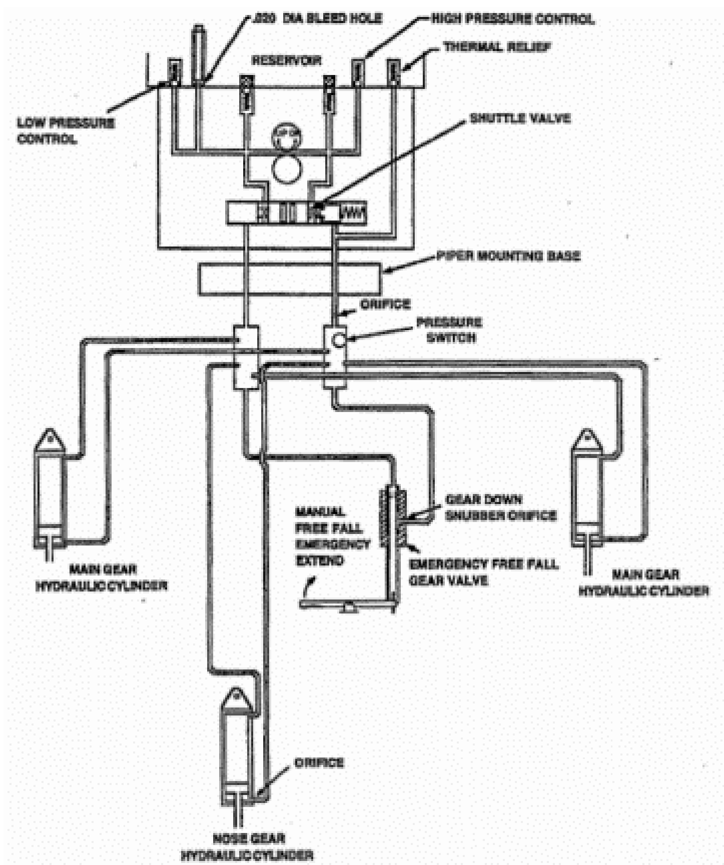
b. Indications
- Gear down and locked is indicated by 3 green lights
- A red Warning Gear Unsafe light illuminates when the gear is in transit, or not in the full up or locked down position
- Do not retract above 107 KIAS

- Do no extend above 129 KIAS

ii. Nose Gear
   a. Steerable through a 30° arc each side of center through the use of the rudder pedals
      - As the nosewheel retracts, the steering linkage disengages to reduce rudder pedal loads in flight
   b. Bungee assembly is also included to reduce ground steering effort and dampen shocks and bumps during taxi
   c. Oleo strut of the air-oil type. Normal extension is 2.75 ± 0.25" when at the empty weight of the aircraft plus full fuel and oil
   d. Equipped with a hydraulic shimmy damper to reduce nose wheel shimmy

iii. Main Gear
   a. Main gear wheels have single disk hydraulic brake assemblies
   b. Oleo strut of the air-oil type. Normal extension is 2.50 ± 0.25" when at the empty weight of the aircraft plus full fuel and oil

iv. Emergency Extension
   a. Holding the emergency gear lever in the down position manually releases hydraulic pressure and permits the gear to free fall
      - The nose gear is spring assisted

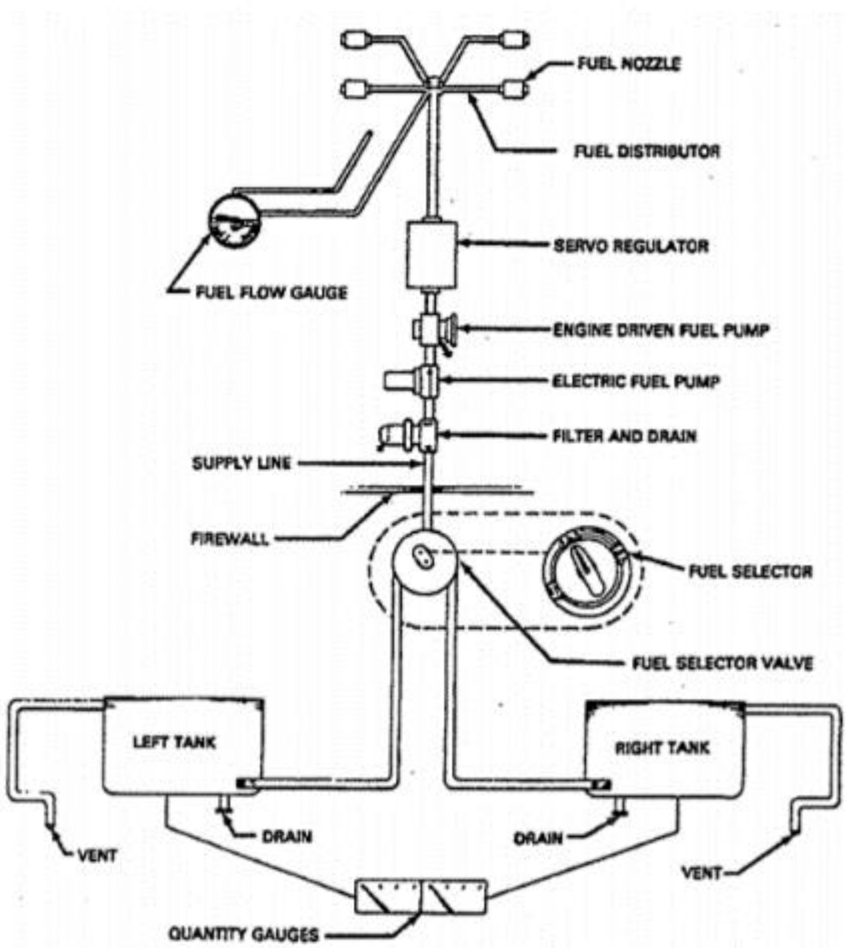


v. Gear Warning Horn
   a. Warning horn and Warning Gear Unsafe light under the following conditions:
      - Gear up and power reduce below approximately 14" of manifold pressure
      - Gear selector switch UP while on the ground and throttle in the retarded position
      - Whenever the flaps are extended beyond the approach position (10°) and the landing gear are not down and locked

vi. Brake System
   a. Components
      - Dual toe brakes attached to the rudder pedals
      - Hand lever
      - Master cylinder
   b. Operation
      - The toe brakes and hand brake have their own brake cylinders, but share a hydraulic reservoir
      - The parking brake is incorporated in the lever brake and is operating by pulling back on the lever, depressing the knob on the top of the handle, and releasing the brake lever
         a To release the parking brake, pull back on the brake lever to disengage the catch mechanism and allow the handle to swing forward

5. Fuel, Oil, and Hydraulic

A. Fuel
   i. Tanks
      a. Two 38.5 gallon tanks, one in each wing (36 gallons usable)
         - Of the 77 total gallons, 72 gallons are usable
         - 2.5 gallons unusable fuel per tanks
      b. Each tank is equipped with a filler neck indicator tab to aid in determining fuel remaining when the tanks are not full
         - Usable capacity to the bottom of the indicator is 25 gallons
      c. The tanks are vented individually by a vent tube protruding from the bottom of the wing at the rear inboard corner of each tank
         - Check vents periodically to ensure they are not obstructed
   ii. Fuel Pumps
      a. Two fuel pumps – An engine driven pump and an auxiliary electric fuel pump
         - Aux electric pump is provided as a backup feature and should be on when switching fuel tanks, and during takeoff and landing
   iii. Operation
      a. Main tanks → Fuel Selector → Filter and Drain → Electric Fuel Pump → Engine Fuel Pump → Servo Regulator → Fuel Distributor
   iv. Fuel Selector
      a. Selections: Left Tank, Right Tank, OFF
         - The selector also incorporates a safety latch to prevent inadvertent selection of OFF
   v. Indications
      a. Quantity and pressure are indicated in gauges located in a cluster on the instrument panel



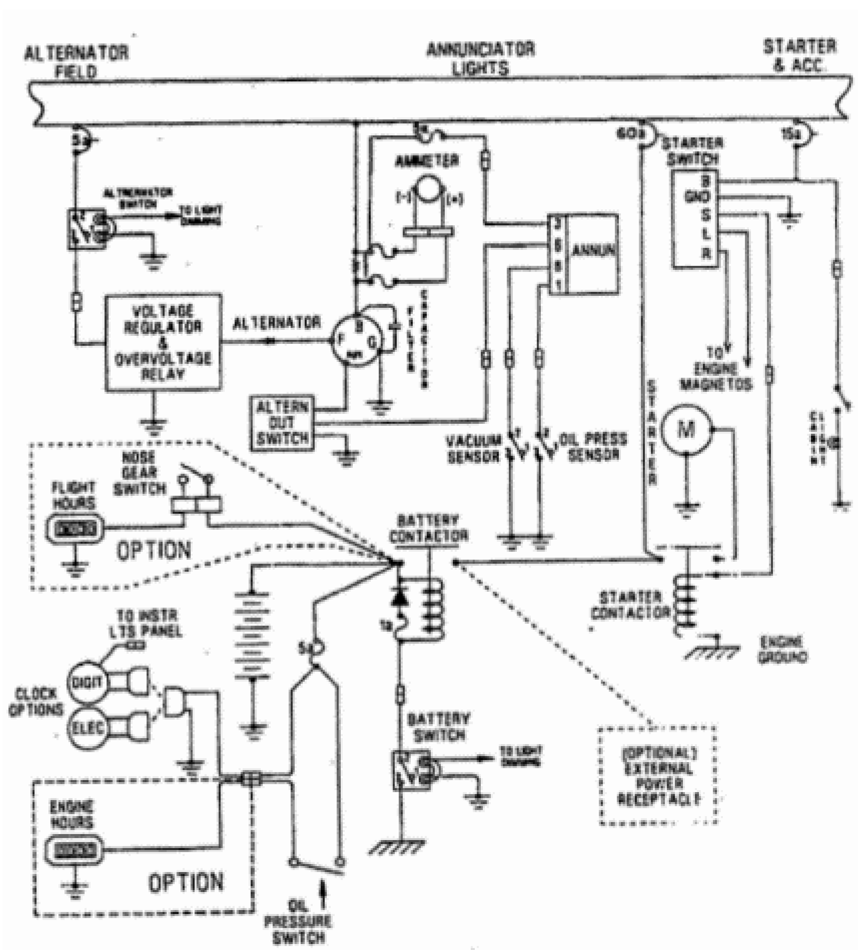
B. Oil System
   i. Wet sump oil system
      a. Oil is drawn from the sump to the oil cooler, then to the pressure relief valve, and on to the engine and then by gravity back to the sump
         - Oil Cooler – in the even that cold oil or an obstruction restricts flow to the cooler, and oil cooler bypass is provided
         - Oil Pressure Relief Valve – regulates the engine oil pressure by allowing excess oil to return to the sump
   ii. Capacity: 8 quarts
C. Hydraulic
   i. The engine has no hydraulic system. See Brake System above for aircraft hydraulics

6. Electrical

A. General
   i. 14 volt, 60 amp alternator
      a. Provides full electrical power even at low engine RPM
      b. Protected by an alternator control unit that incorporates a voltage regulator and overvoltage relay
   ii. 12 volt, 35 amp hour battery
B. Consumers
   i. Standard accessories include: alternator, starter, electric fuel pump, stall warning horn, ammeter, and annunciator panel

- ii. Optional accessories include: navigation, ground recognition, anti-collision, landing, instrument panel, and cabin dome lights
- iii. Circuits will handle the addition of communication and navigation equipment

C. Electrical Monitoring Instruments
- i. Ammeter
  - a. The ammeter displays the load placed on the alternator (it does not indicate battery discharge)
    - With all electrical equipment off the ammeter will be indicating the amount of charging current demanded by the battery
    - As each electrical item is turned on, the current will increase to a total appearing on the ammeter (this total includes the battery)
    - The average continuous load for night flight, with radios on, is about 30 amperes. The 3 ampere value, plus approximately 2 amperes for a fully charged battery will appear continuously under these flight conditions
  - b. The amount of current shown on the ammeter will tell immediately if the alternator system is operating normally, as the amount of current shown should equal the total amperage drawn by the equipment operating
- ii. Annunciator Panel
  - a. Includes various indications provided as a warning to the pilot that a system may not be operating properly, and the pilot should check and monitor the applicable system to determine if or when any necessary action is required (i.e. alternator indicator light)

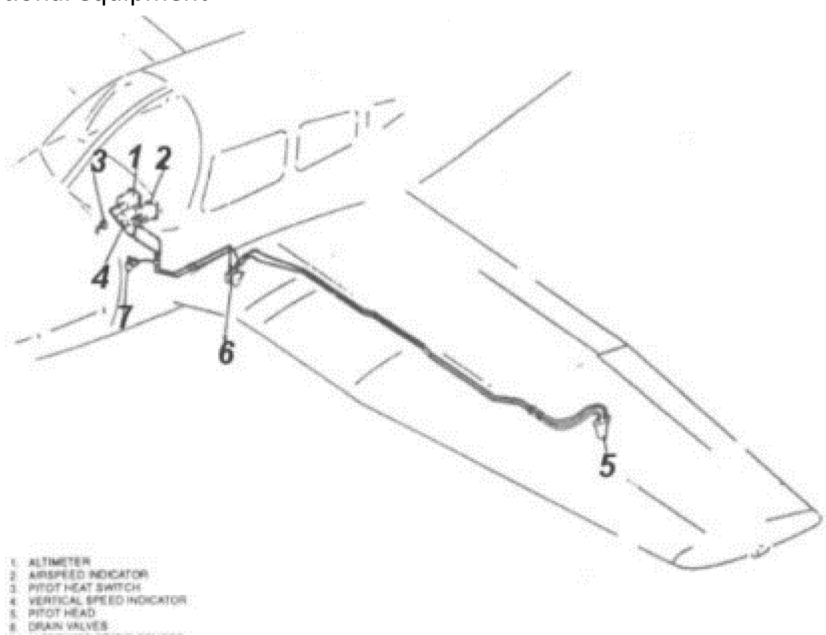


7. Avionics

A. Avionics will vary based on model and options
   i. Operating instructions should be taken from the manuals of the respective manufacturers
B. Radios are located in the center section of the panel
   i. A ground clearance energy saver system is available to provide direct power to COMM 1 without turning on the battery master, and radio master (if installed)
      a. When the switch is ON, battery power is supplied to COMM 1 speaker and radio accessories
      b. Ensure the GND CLC switch is off when not required to prevent depletion of the battery when the engine is shutdown
   ii. Circuits are available for addition of optional radio equipment

8. Pitot-static, Vacuum Pressure, and Associated Flight Instruments

A. Pitot-Static
   i. Supplies pitot and static pressure for the airspeed indicator, altimeter, and vertical speed indicator
   ii. Components
      a. Pitot head – located on bottom left of the wing
      b. Static Vents – button type vents on each side of the aft fuselage
      c. Pitot and Static lines – carry pitot and static pressures through the wing and fuselage to the gauges on the instrument panel
      d. Alternate Static Source – If installed, allows the pilot to select an alternate static source from inside the aircraft for the altimeter, vertical speed indicator, and airspeed indicator
         - The storm window and cabin vents must be closed
         - The cabin heater and defroster must be on
         - The altimeter error is less than 50’ unless otherwise placarded
   iii. Pitot Heat – optional equipment



B. Vacuum Pressure (Gyros)
   i. Designed to operate the air driven gyro instruments – directional gyro and attitude indicator
   ii. Components - Engine driven vacuum pump, Vacuum regulator, Filter, and the necessary plumbing
   iii. Vacuum Gauge
      a. A decrease in pressure (low vacuum indicator light) that remains constant over an extended period may indicate a dirty filter, dirty screens, a sticking vacuum regulator or a system leak

    b. Zero pressure indicates a sheared pump drive, defective pump, a defective gauge or collapsed line
  iv. Vacuum Regulator
    a. Protects the gyros
    b. The valve is set so normal operation reads 5.0 ± .1 inches of mercury
      - Higher settings will damage the gyros, lower settings will result in unreliable indications
C. Electrically Driven Instruments
  i. Turn and Bank indicator
  ii. As necessary, other installed electrical equipment

9. Environmental

A. Cabin Heat and Defrost
    a. Components
      - Heat shroud, Heat ducts, Defroster Outlets, Heat and Defroster Controls
    b. Operation
      - Cabin Heat: An opening in the front of the lower cowling allows ram air to the heater shroud. The warmed air travels to the heater shut-offs on the right and left side of the firewall. When the shut-offs are opened, the heated air enters the ducting along each side of the center console and to the outlets in the cabin
        a Cabin temperature is set by the heater control on the right side of the instrument panel
      - Defrost: Heated air is ducted to shut-off valves at the firewall, then to the defroster outlets
        a Airflow is regulated by a defroster control located below the heat control
      - To aid in air distribution, cabin air is exhausted overboard by an outlet located on the bottom of the fuselage
        a This is removed if air condition is installed
B. Fresh Air Inlets
  i. Fresh air is supplied from an air inlet on the side of the left aft fuselage beneath the dorsal fin
    a. Amount and direction of air can be regulated at individual outlets
C. Blower (if installed)
  i. Forces outside air through the overhead vents for ground use
D. Air Conditioning (if installed)
  i. Recirculating air system
  ii. Consists of: Evaporator, scoop, condenser, compressor, blower, switches, and temperature controls
  iii. Controls are located on the lower right side of the instrument panel
    a. Temp Control, Fan Speed, On/OFF
  iv. Operation
    a. Air from the baggage area is drawn through the evaporator by the blower and distributed through an overhead duct to individual outlets located adjacent to each passenger
  v. Whenever the throttle is in the full forward position, it actuates a micro switch which disengages the compressor and retracts the scoop to obtain maximum power and rate of climb
    a. When the throttle is retarded approximately 1”, the system will turn back on

10. Deicing and Anti-Icing

A. Defrost
  i. Can be used to deice the windshield (if the icing is light)
B. Pitot Heat (if installed)
  i. Helps to alleviate problems with icing and heavy rain

Conclusion:
Brief review of the main points
A thorough understanding of the airplane’s systems makes a safer, smarter pilot.

II.F. Performance & Limitations

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The learner develops knowledge of the elements related to airplane performance and limitations.
Key Elements	1. Density 2. Density Altitude 3. Airplane Performance
Elements	1. Performance 2. Performance Factors 3. Aerodynamics 4. Performance Charts 5. Weight & Balance 6. Exceeding Limitations
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can calculate weight & balance, and performance and properly apply the information to the specific aircraft and its limitations as well as the operating environment (runway, terrain, cruise altitude, airspeeds, etc.).

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

How exciting would it be to find out firsthand that the airplane doesn't have the ability to takeoff from a certain runway and that it also doesn't have the ability to clear the obstacle at the departure end?

Overview

Review Objectives and Elements/Key ideas

What

The Performance and Limitations section of the POH contains the operating data for the airplane; that is, the data pertaining to takeoff, climb, range, endurance, descent, and landing. Additionally, airplane weight and balance is basically balancing the airplane within approved limits (also in the aircraft's limitations)

Why

The use of the operating data for the airplane is mandatory & critical for safe and efficient operations

How:

1. **Performance & Limitations**
    A. Ability of an aircraft to accomplish certain things that make it useful for a certain purpose
        i. Ex: Short takeoff and landing distance, the ability to carry heavy loads, long distance, high speed, etc.
    B. Primary factors most affected by performance are:
        i. Takeoff/landing distance, climb rate, ceiling, payload, range, speed, maneuverability, stability, fuel economy
        ii. Focusing on one or more of these capabilities dictates differences between aircraft & their specialization(s)
    C. Aircraft and powerplant design & characteristics dictate available performance
        i. Manufacturer will match aerodynamic configuration with a powerplant to provide max performance for the specific design conditions
    D. POH charts and information are used to measure performance based on the specific flight's conditions
        i. Various factors affect the airplane's performance on any given day
        ii. To make practical use of the plane's capabilities & limitations it is essential to understand performance data
2. **Performance Factors**
    A. Atmospheric Conditions AI.II.F.K2a
        i. Atmospheric Pressure
            a. Though air is light, it has mass and is affected by gravity and therefore it has a force
            b. Under standard conditions at sea level, the average pressure exerted is approx. 14.7 lbs. per sq. in
            c. Since air is a gas, it can be compressed or expanded
            d. Density of the air has significant effects on the airplane's performance
                - As the density of the air increases, airplane performance increases and vice versa
        ii. What Changes Air Density (DA)?
            a. Barometric Pressure, Temperature, Altitude, and Humidity all affect air density
                - Density varies directly with pressure - As pressure increases, density increases and vice versa
                - Density varies inversely with temperature – As temp increases, density decreases and vice versa
                - Density varies inversely with altitude - As altitude increases, density decreases and vice versa
                - Density varies inversely with humidity – As humidity increases, density decreases and vice versa
                    a More specifically: For a given volume of atmospheric air, as humidity increases some of the dry

air is replaced by water vapor

1. The molecular weight of dry air is approximately 29 grams/mol, while the molecular weight of water vapor (H_20) is about 18 grams/mol
   a. Grams/mol = Molar mass
2. As the proportion of water in the atmosphere (humidity) increases, the density (weight/volume) of the air decreases

iii. How it affects Performance
   a. As the air becomes less dense, it reduces:
      - Power, since the engine takes in less air
      - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
      - Lift, because the thin air exerts less force on the airfoils

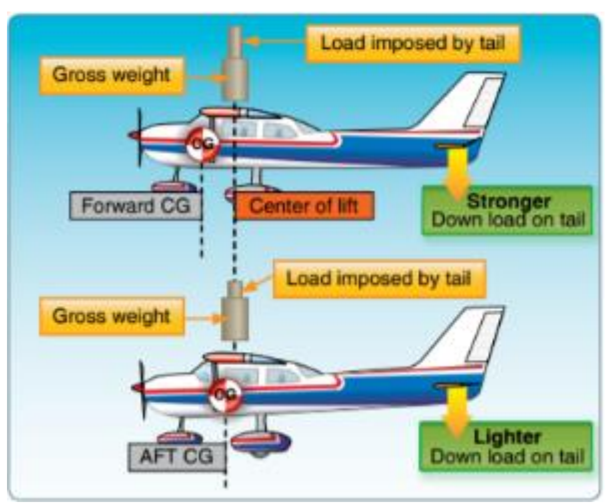
iv. High altitude, high temperature airports may not allow safe operation
   a. Always be aware of the density altitude and accompanying performance when planning a flight
   b. If necessary, delay until the performance is attainable, or reduce weight to attain the performance

B. RM: Pilot Technique & Airplane Configuration AI.II.F.K2b, AI.II.F.K2c, AI.II.F.R3
(RM: Difference between calculated & actual performance)
   i. Performance is based on specific aircraft configuration, procedures, airspeeds, etc.
   ii. Any technique or configuration that differs from POH criteria will change (likely reduce) performance
   iii. Essential to adhere to POH specified criteria and procedures to attain the performance described in the POH
      a. Deviating from these procedures reduces safety and more or less moves into the realm of a test pilot
         - No guarantees of published performance

C. Airport Environment AI.II.F.K2d
   i. Airport Runways & Layout
      a. Runway Surface
         - Paved, grass, dirt, gravel, etc.
         - Any surface that is not hard and smooth increases ground roll
            a Increased friction and reduced acceleration
         - Braking Effectiveness
            a Soft surfaces will slow an aircraft much faster than smooth and slick surfaces
            b Wet runways reduce braking effectiveness and can result in hydroplaning
         - Regarding performance, landing tends to be less restrictive than takeoff
            a Ensure you can takeoff from an airport prior to landing there
               1. Ex: Landing on a short runway, then refueling and picking up a passenger, or a change in winds may prohibit takeoff
      b. Runway Gradient
         - Amount of change in height over the length of the runway, expressed as a percentage
            a 3% gradient means that for every 100' of runway, the height changes by 3'
               1. Takeoff: Down sloping aids in acceleration and reduces ground roll and vice versa
               2. Landing: Down sloping increases landing distance and vice versa
      c. Runways available based on wind conditions
         - Headwind versus crosswind or tailwind
            a Headwind provides the most favorable performance, tailwind the least favorable
            b Be conservative: When calculating performance with varying winds, use the most restrictive wind direction (i.e. winds variable from 090 to 150°, departing runway 36 – use 150° winds)
   ii. Surrounding Terrain & Factors (Obstacles, towers, buildings, etc.)
      a. Can the aircraft clear the obstacles based on the specific conditions?
      b. Is a max angle versus max rate of climb required

c. Are there specific noise abatement departure/arrival procedures requiring specific performance

D. Loading and Weight and Balance AI.II.F.K2e
   i. Weight and Flight Performance
      a. Any added weight reduces aircraft performance
      b. Manufacturer's limit maximum weights to ensure aircraft performance / structural abilities
         - Verify required performance based on the airplane weight and current conditions
      c. Effects of increased weight
         - Higher takeoff speed and longer takeoff run
         - Reduced rate and angle of climb
         - Lower maximum altitude
         - Slower cruise speed and reduced range, and increased fuel consumption
         - Reduced maneuverability
         - Higher stall speed
         - Higher approach speed and longer landing roll
         - Excessive weight on the nose / tail wheel
      d. RM: Effects of Overloading (RM: Exceeding weight limits) AI.II.F.R4
         - Degraded climb performance, may not even be able to takeoff
            a Even a minor overload may make it impossible to clear an otherwise normal obstacle
            b May not be able to reach manufacturer's published maximum altitudes
         - Overheating during climbs, added wear on engine parts
         - Overstressing the aircraft
   ii. RM: Weight and Structure (RM: Exceeding weight limits) AI.II.F.R4
      a. In loading an aircraft, the structure must be considered
         - Structural failures which result from overloading may be catastrophic, but they often affect structure progressively, making it difficult to detect or repair
         - Airworthiness requirements prescribe that the structure of an aircraft can withstand a specific load factor (3.8 Gs for normal category)
            a This means the primary structure can withstand a load of 3.8 times the approved gross weight of the aircraft without structural failure occurring
            b Any overload is amplified in the case the aircraft is stressed to these G limits
               1. For example, a 100 lb. overload imposes a potential structural overload of 380 lbs.
         - Even seats, baggage compartments, and cabin floors are designed for a certain load
         - Follow the manufacturer's guidelines and placards in regard to weight
      b. Habitual overloading tends to cause cumulative stress and damage that may not be detected and result in structural failure later, during normal ops



   iii. Stability and Controllability
      a. An airplane with forward loading
         - A forward CG/nose-heavy condition causes problems controlling and raising the nose, especially at slow airspeeds (takeoff and landing)
            a During landing, exceeding the forward CG limit may result in excessive loads on the nosewheel, higher stalling speeds and higher control forces
            b In extreme cases, it may be difficult or

impossible to flare for landing

- The airplane is "heavier" and consequently slower than the same airplane with a further aft CG
  - a Additional back pressure than normally would be required is necessary to maintain altitude
  - b The added back pressure requires the tail surfaces to produce a greater down force
  - c The greater down force adds to wing loading, increasing the total lift required from the wings
  - d Thus, the nose heavy aircraft requires a higher AOA to maintain altitude, which results in more drag and, in turn, produces a higher stalling speed
- The airplane is more controllable in a stall
  - a The longer arm from the CG makes the elevator more effective
  - b The nose heavy loading results in a tendency for the nose to drop, or assist in breaking the stall

b. An airplane with aft loading

- A tail-heavy condition has serious effect upon longitudinal stability, and reduces the capability to recover from stalls and spins
  - a It also produces very light control forces, another undesirable characteristic
    1. Very easy to overstress the airplane
- The airplane is "lighter" and consequently faster than the same airplane with a more forward CG
  - a Less back pressure than normally would be required is necessary to maintain altitude
  - b The reduced back pressure requires less down force from the tail surfaces
  - c The reduced down force reduces wing loading, decreasing the total lift required from the wings
  - d Thus, tail heavy loading requires a lower AOA to maintain altitude, which results in less drag, and in turn, produces a lower stalling speed
- Although the stall speed is lower, the airplane less controllable in a stall as the CG moves aft
  - a The airplane is less controllable due to the shorter arm from the CG to the elevator
    1. Greater deflection is required to produce the same result as with a farther forward CG
  - b The tail-heavy aircraft also has less of a tendency to pitch down in the case of a stall
    1. There is a point in rearward loading of an aircraft at which a flat spin develops
       a. A flat spin is impossible to get the nose down and recover from

c. The CG and Lateral Loading

- Unbalanced lateral loading (more weight on the right or left side of the aircraft centerline) may result in adverse effects
  - a This can be caused by fuel imbalance, people, baggage, etc.
- Compensate for any imbalance with trim (if available), or constant control pressure
  - a Places the aircraft in an out-of-streamline condition, increasing drag, and decreasing efficiency

d. RM: Operating outside of CG limits results in control difficulties AI.II.F.R5

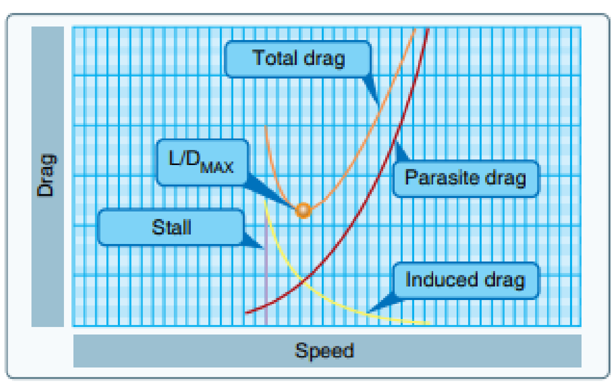
- Extremely nose or tail heavy – May not have control authority

3. Aerodynamics AI.II.F.K5

A. Straight-and-Level

i. To maintain straight-and-level, lift must equal weight and thrust must equal drag
   a. Drag defines the thrust required to maintain steady, level flight

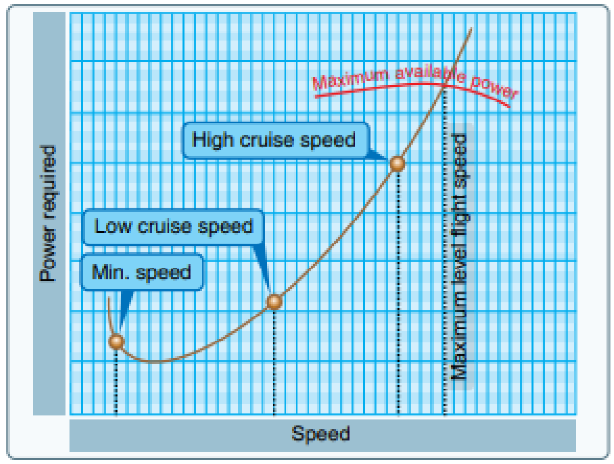
ii. Parasitic drag predominates at high speed, induced drag predominates at low speed (pictured, right)
   a. If an aircraft at steady flight at 100 knots is accelerated to 200 knots:
      - Parasite drag becomes 4x as great
      - Power to overcome that drag is 8x the original



value
- Induced drag is ¼ the original value
- Power to overcome that drag is ½ the original value

iii. The max level flight speed is obtained when power required equals max power or thrust available from the powerplant (pictured, right)

iv. Min level flight speed is generally not defined by thrust/power requirements since stall or stability occur first (pictured, right)



B. Climb Performance

i. Mechanical energy comes in two forms: Kinetic and Potential Energy

a. Kinetic Energy (KE): Energy of speed
- Aircraft motion (KE) is described by airspeed
- Directly proportional to the square of the airspeed
- $KE = \frac{1}{2} \times m \times v^2$
  - a m = mass, v = velocity

b. Potential Energy (PE): Stored energy
- Aircraft position (PE) is described by altitude
- Directly proportional to the altitude
- $PE = m \times g \times h$
- m = mass, g = gravity field strength, h = object height

ii. Power & Thrust

a. Power and thrust are not synonymous

b. Thrust: Force or pressure exerted on an object
- Measured in pounds or newtons

c. Power: Measurement of the rate of performing work or transferring energy (KE & PE)
- Measured in horsepower or kilowatts
- The motion (KE and PE) a force (thrust) creates when exerted on an object over time

iii. Positive climb performance occurs when an aircraft gains PE by increasing altitude

a. Two factors contribute to gaining altitude:
- Factor One: Aircraft uses excess power above what's required to maintain level flight
  - a Ex. 200 hp engine is only using 130 hp to maintain level flight (70 hp available to climb)
    1. Increase power, maintains airspeed and climbs
- Factor Two: Aircraft converts airspeed (KE) to altitude (PE)
  - a Ex. Level airplane at 120 knots
    1. Increase back pressure to climb, airspeed is reduced as altitude increases

iv. Two reasons to evaluate climb performance

a. Aircraft must climb over obstacles to avoid hitting them

b. Climbing to higher altitudes can provide better weather, fuel economy, etc.

C. Angle of Climb (AOC)

i. Comparison of altitude gained relative to distance traveled

a. For max AOC performance, the aircraft is pitched for V_X
- Provides max altitude increase with minimum horizontal travel over the ground

ii. Max AOC occurs at the airspeed and AOA combination resulting in the maximum excess *thrust*

a. Factor One, discussed above

b. The airspeed and AOA combination where max excess thrust exists differs amongst aircraft types
   - Jet: Approximately L/D_{MAX}
   - Propeller Plane: Below L/D_{MAX} and just above stall speed

iii. Ex: Short field takeoff surrounded by high obstacles

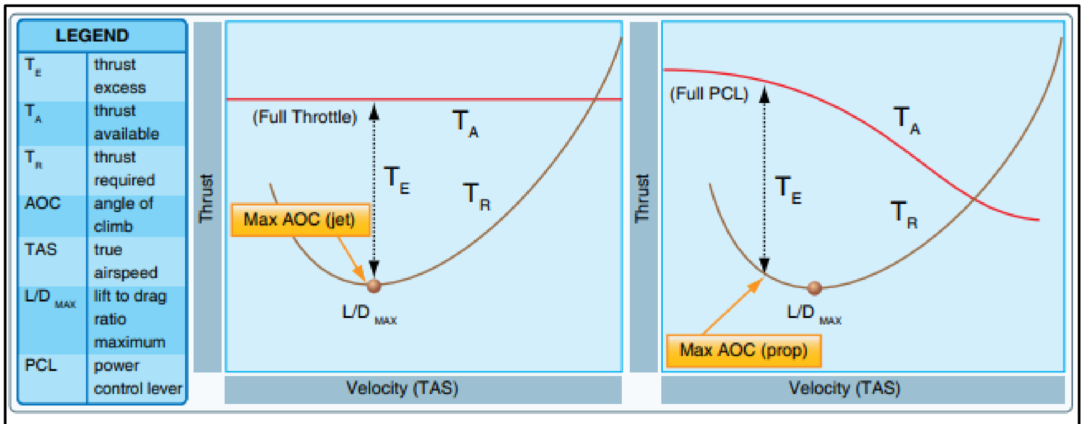


Figure 11-8. *Comparison of maximum AOC between jet and propeller airplanes.*

D. Rate of Climb (ROC)

i. Comparison of altitude gained relative to the time needed to reach that altitude

a. For max ROC performance, the aircraft is pitched for V_Y
   - Provides max altitude increase over a given time (irrespective of distance)

ii. ROC performance depends on excess *power* (versus thrust for max AOC)

a. Airspeed and AOA combination where max excess power exists also differs among aircraft types
   - Jet: At an airspeed > L/D_{MAX} and an AOA < L/D_{MAX} AOA
   - Propeller Plane: Airspeed and AOA combination closer to L/D_{MAX}

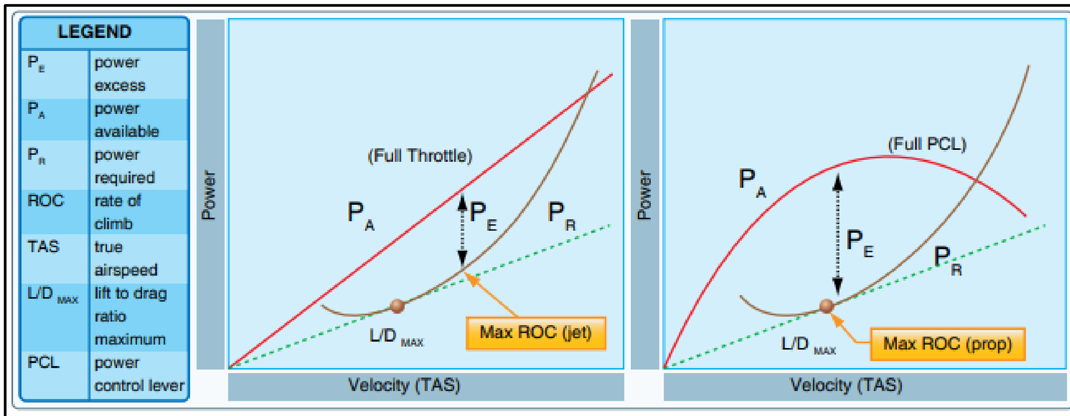


Figure 11-9. *Comparison of maximum ROC between jet and propeller airplanes.*

E. Climb Performance Factors

i. Weight, altitude, and configuration changes affect excess thrust & power and therefore climb performance

a. Increased weight/altitude and lowering the flaps/gear decrease both excess thrust & power
   - Maximum AOC and ROC decrease under any of these conditions

ii. Weight

a. Any added weight means the aircraft must fly at a higher AOA to maintain a given altitude & speed
   - Increases induced drag and parasite drag
   - Increased drag requires additional thrust

- Additional thrust means there is less reserve thrust available to climb

b. Designers go to great lengths to minimize weight due to its marked effect on performance

iii. Altitude (pictured, right)

a. Increases power required & decreases power available
- Climb performance diminishes with altitude

b. The speeds for max ROC, AOC, and max/min level flight airspeeds vary with altitude
- As altitudes increases, these speeds all converge at the aircraft's absolute ceiling
  - a At the absolute ceiling, there is no excess power and only one speed allows level flight
- Service ceiling is the altitude at which the aircraft cannot climb > 100 fpm

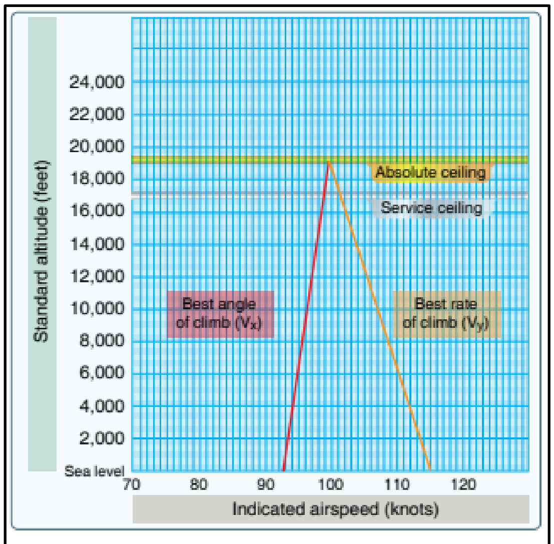
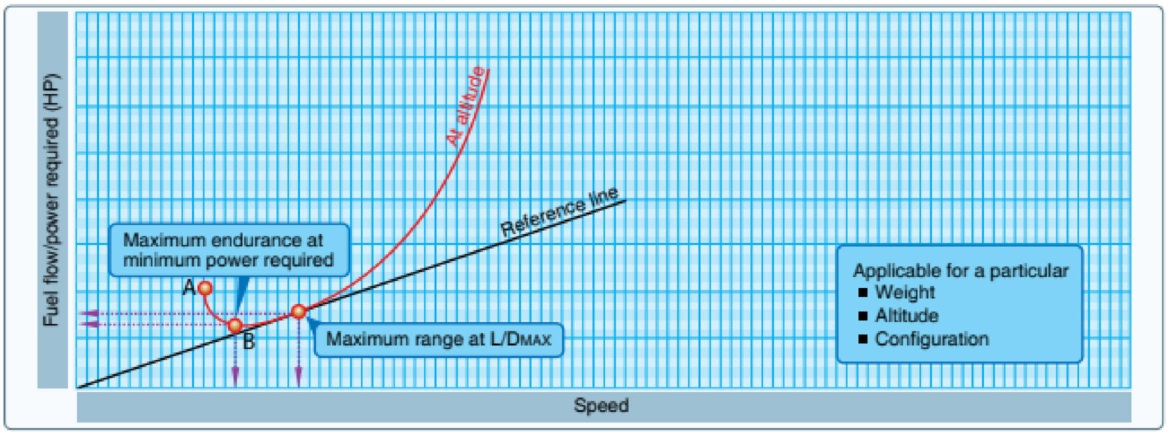


Figure 11-10. *Absolute and service ceiling.*

F. Range Performance



i. The ability to convert fuel into flying distance is one of the most important items of aircraft performance

ii. Range versus Endurance

a. Range involves the consideration of flying distance

b. Endurance involves the consideration of flying time

iii. Maximum Endurance (Time)

a. If max endurance is desired, the flight condition must provide minimum fuel flow (point B in the chart)

b. Point A (low speed, high fuel flow) is takeoff and climb

c. As airspeed increases, power and fuel requirements decrease due to aerodynamic factors up to Point B

d. Beyond Point B, you must pay to go faster (more airspeed requires more power at the cost of fuel)

iv. Maximum Range

a. Costs aside, max range is the flight condition providing max NM per pound of fuel (or specific range)
- Specific Range = NM / pounds of fuel
  - a Ex: Specific range of 1.89 means for every pound of fuel, the aircraft could fly 1.89 miles
  - b Can also be described as the maximum speed per fuel flow (knots / fuel flow)

b. Obtained at L/D_{MAX} and varies with gross weight, altitude, and configuration
- As fuel is burned, gross weight changes, and therefore optimum altitude, airspeed, & power changes
- L/D_{MAX} occurs at a specific AOA & lift coefficient, irrespective of weight
  - a Changes in weight alter the specific airspeed and power required to attain L/D_{MAX}
- To maintain the maximum range, optimum conditions must be maintained

        a If fuel is a small part of weight (short range), could be as easy as setting one speed/altitude
        b If fuel is considerable part of weight (long-range), airspeed & power changes are necessary
    c. Headwinds & Tailwinds
        - Theories say that speeding up in a headwind & slowing in a tailwind helps achieve max range
        - May be true in many cases, but there are many variables to every situation – no catch all rule
    d. Most long-range cruise flights are operated at 99% max specific range
        - 1% of range is traded for 3-5% higher speed
    e. Reciprocating engine aircraft experience little, if any, variation in specific range up absolute altitude

4. Performance Charts AI.II.F.K1

A. Using Performance Charts
  i. Airplane performance is found in Section 5 of the POH (Performance and Limitations)
    a. *Supplement 4, for the DA20 (any charts not shown in the supplement are found in Chapter 5)
  ii. Using the performance charts, and the accompanying instructions, we can calculate
    a. Cruise Performance
    b. Stall Speeds based on airplane configuration
    c. Wind Components (Crosswind and Headwind)
    d. Takeoff Distance and Landing Distance
    e. Climb Performance (In cruise and takeoff configurations as well as Balked Landing)
    f. True Airspeed
    g. Maximum Flight Duration (Pressure Altitude is combined with RPM to find % bhp, KTAS, GPH)
  iii. To make use of these charts we need to know the Pressure Altitude (PA)
    a. Pressure Altitude (PA) – The altitude indicated when the altimeter setting window is set to 29.92
        - PA = 1,000(29.92-Current Altimeter Setting) + Elevation
            a EX: Altimeter = 30.42 and Elevation = 808, so PA = 308’
            b EX: Altimeter = 29.84 and Elevation = 808, so PA = 888’
    b. From Pressure Altitude we can compute Density Altitude (DA)
        - DA: PA corrected for non-standard temperature (Directly related to airplane performance)
        - DA = 120(Current Temperature - ISA Temperature) + PA
            a EX: Temp = 23°C, ISA = 15° C, PA = 308’, so DA = 1,268’
            b EX: Temp = 03°C, ISA = 15 ° C, PA = 308’, so DA = -1,132
            c This is a very good estimate of DA, the equation is not perfect
  iv. *Once we have PA, we can start at the temperature at the bottom of the chart and move up to the PA
    a. From there, we move straight across until we reach the next stage of the chart
        - Once we reach the next step, follow the trend line and then move straight across
  v. This is done until we reach the performance number

B. Determining the Required Performance is Attainable
  i. Use the performance charts and relate them to the airport information (runway lengths, etc.)
    a. The charts will provide performance for all phases of flight
    b. But remember, the charts don’t make allowance for pilot proficiency or mechanical deterioration
        - Does the airplane have problems that may limit performance?
  ii. There is always the possibility of changing weather resulting in useless original calculations
    a. Just because the plane will perform well now doesn’t mean it will perform well later
    b. Plan ahead

C. RM: Inaccuracies (RM: Use of performance charts, tables, and data) AI.II.F.R1
  i. Ensure you are using the proper chart
    a. i.e., some aircraft have numerous takeoff charts (broken down by type of takeoff and then weight)
        - Short field vs normal takeoff at 2400 vs 2500 pounds

ii. Many charts are imprecise (small, detailed lines through various charts, and/or complicated tables)
  a. Be as accurate as possible, double check work and verify if the performance information makes sense
iii. Eliminate human error as much as possible

D. RM: Calculated versus Actual Performance AI.II.F.R3
  i. Calculated performance is based on the POH chart assumptions (configuration, airspeeds, etc.)
    a. Anything different leads to different (generally, reduced) actual performance
      - Changing weather/wind conditions, configuration, pilot technique and airspeeds flown, etc.
  ii. Be conservative in performance calculations and precise in flying

5. Weight & Balance

A. Terms AI.II.F.K3
  i. Reference Datum (RD) - an imaginary vertical plane or line from which all measurements of arm are taken
    a. The datum may be located anywhere the manufacturer chooses
    b. Common locations are the nose, the engine firewall, the wing's leading edge, or ahead of the nose
    c. Once the datum is selected, all moment arms and the location of CG range are measured from this point
  ii. Center of Gravity (CG) – the point at which an airplane would balance if it were suspended at that point
    a. The distance of the CG from the RD is found by dividing the total moment by total weight
  iii. Arm – the horizontal distance in inches from the reference datum line to the CG of an item
    a. Plus (+) = measured aft of the datum
    b. Minus (-) = measured forward of the datum
    c. If the RD is ahead of the nose, all the arms are positive
  iv. Basic Empty Weight – the weight of the standard airplane, optional equipment, unusable fuel, and full operating fluids (including oil)
  v. CG Limits – the specified forward and aft points within which the CG must be located during the flight
  vi. Maximum Landing Weight – the greatest weight that an aircraft is normally allowed to have at landing
  vii. Maximum Ramp Weight – the total permitted weight of a loaded aircraft, including all fuel
    a. It is greater than the takeoff weight due to the fuel that will be burned during taxi and run-up
    b. Also referred to as taxi weight
  viii. Maximum Takeoff Weight – the maximum allowable weight for takeoff
  ix. Maximum Zero Fuel Weight – the maximum weight, exclusive of usable fuel
  x. Moment – the product of the weight of an item multiplied by its arm and expressed in pound-inches
    a. Total moment is the weight of the airplane multiplied by the distance between the datum and CG
  xi. Moment Index – a moment divided by a constant such as 100, 1,000 or 10,000
    a. The purpose is to simplify weight and balance computations
  xii. Payload – the weight of the occupants, cargo, and baggage
  xiii. Standard Weights – established weights for numerous items in weight and balance computations
    a. Gas – 6lbs; Jet Fuel – 6.8 lbs.; Oil – 7.5 lbs.; Water – 8.35 lbs. (All per gallon)
  xiv. Station - a location in the plane identified by a number designating its distance in inches from the datum
    a. The datum is, therefore, identified as station zero
    b. An item located at station +50, would have an arm of 50"
  xv. Unusable Fuel – the fuel in the tanks that cannot be safely used in flight or drained on the ground
  xvi. Usable Fuel – the fuel in the tanks that can be used for flight
  xvii. Useful Load – the basic empty weight subtracted from the maximum allowable gross weight

B. Weight & Balance Control
  i. The pilot is responsible
    a. 14 CFR Part 23.2100 requires ranges of weights and CGs within which aircraft may be safely operated
      - The manufacturer provides this information in the POH/AFM
    b. Part 91.9 requires the PIC to comply with the operating limitations in the approved AFM
    c. The pilot, therefore, is responsible for loading and fuel management of the aircraft

- Before every flight, determine the weight and balance condition and ensure it is within limitations
- Often it is not possible to fill all seats, baggage compartments, and fuel tanks and stay in limits
    - a The pilot will need to adjust accommodate the required load
        1. Remove passengers, reduce fuel load/baggage, etc.

ii. The aircraft owner/operator should ensure up to date information is available to the pilot and the appropriate entries are made in the records for repairs/modifications

C. Determining Weight and Balance AI.II.F.K4

i. CG = Total Moment divided by Total Weight

a. Begin with the empty weight and make a list of everything that will be loaded in the airplane
- People, items, and fuel (note the weights of everything as well)
- Be sure the total weight of what you want to load is within the maximum weight limits
    - a If the total weight is too high, remove items/fuel/people to get within weight limits

b. Calculate the Moment of each item
- To find the moment, use the graph or multiply the weight by the arm in the POH
    - a Use the method provided in the AFM
    - b The weight/moment of the empty airplane are found in its weight and balance documents

c. Then calculate the CG – (Total Moment/Total Weight)
- *For the DA20, compare the Total Weight and Total Moment on the graph in Supplement 4

d. *Use the chart in Supplement 4 to determine whether the airplane is within limits

ii. RM: Weight Change and/or CG Shift (RM: Shifting, adding, and removing weight) AI.II.F.R6

a. Shifting Weight
- Formula: $\frac{Weight\ to\ be\ Shifted}{Total\ Weight} = \frac{\Delta\ CG}{Distance\ Weight\ is\ Shifted}$
    - a If you know 3 of the components, you can solve for the 4th
- For example, if the total weight of the aircraft is 8,000 pounds, and you move a 100 pounds of baggage 120", how much did the CG move?
    - a $\frac{100}{8{,}000} = \frac{\Delta CG}{120} \longrightarrow 12{,}000 = 8{,}000 * \Delta CG \longrightarrow \Delta CG = \frac{12000}{8000} \longrightarrow \Delta CG = 1.5"$
    - b In this case, the CG moved 1.5" (add or subtract it from the original CG as appropriate)

b. Adding or Removing Weight
- Formula: $\frac{Weight\ Added\ or\ Removed}{New\ Total\ Weight} = \frac{\Delta CG}{Distance\ between\ the\ Weight\ and\ old\ CG}$
    - a Just like above, solve for the missing component
- For example, if the airplane weighs 6,100 pounds, with a CG at 80", where does the CG end up if 100 pounds is removed from station 150?
    - a $\frac{100\ pounds}{6{,}000\ pounds} = \frac{\Delta CG}{150" - 80"} \longrightarrow 7{,}000 = 6{,}000 * \Delta CG \longrightarrow \Delta CG = \frac{7{,}000}{6{,}000} \longrightarrow \Delta CG = 1.2"$
    - b If the CG is shifting aft, the ΔCG is added to the old CG
    - c If the CG is shifting forward, the ΔCG is subtracted from the old CG
    - d In this case, the CG moved 1.2" forward, and the new CG = 78.8" (80 – 1.2)

6. RM: Exceeding Limitations AI.II.F.R2

A. Operating Limitations are in Chapter 2 of the POH

i. The limits here establish the boundaries in which the airplane can be safely operated

B. Adverse Effects

i. Attempting to takeoff or land without enough runway

a. Can result in a crash into an obstacle or over-running the runway also damaging the plane

ii. Attempting to clear an obstacle that the airplane performance will not allow at a certain weight

a. Can result in crashing into the obstacle

iii. Not having enough fuel to reach the airport of intended landing

a. Can result in an emergency landing, or ditching

iv. Using the wrong type of fuel
   a. Can result in detonation, causing significant damage to the engine, as well as engine failure

v. Exceeding the structural/aerodynamic limits (overweight or outside CG limits)
   a. Can result in airplane damage or structural failure
   b. Airplane control may be hampered, and stall speeds may be affected

vi. Exceeding the maximum crosswind component (20 knots)
   a. This will greatly increase the difficulty of the landing, possibly resulting in a crash
   b. The airplane may not have the ability to stay aligned with the runway, resulting in a crash, or departing the landing surface

Conclusion:

Brief review of the main points

It is very important that before every flight, the pilot ensures the airplane can produce the required performance depending on the airport and atmospheric conditions.

II.G. National Airspace System

References: 14 CFR part 71, 91, AIM, Navigational Charts

Objectives	To develop knowledge of the elements related to the National Airspace System.	
Key Elements	1. Entry Requirements 2. Communications Requirements 3. Visibility Requirements	
Elements	1. Airspace Classes, Operating Rules, Certification, and Equipment Requirements 2. Special VFR 3. Special Use Airspace 4. Other Airspace areas 5. VFR Charts	
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion	
Equipment	1. White board and markers 2. References	
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework	
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions	
Completion Standards	The learner displays the ability to differentiate between the different types of airspace and their respective weather minimums and requirements.	

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Each type of airspace is like a different country. Each type of airspace has its own controllers or rulers, its own rules for those in their 'territory,' and its own benefits or services which are provided to those within its borders. Borders are drawn and there are requirements and permission necessary to enter certain airspaces (e.g. Passport).

Overview

Review Objectives and Elements/Key ideas

What:

Airspace is defined as, "the portion of the atmosphere above a particular land area, especially above a nation." The atmosphere above the United States is divided into several sectors, or classes and in each different airspace class, specific rules apply.

Why:

Different airspaces have been defined to efficiently manage the large amount of air traffic that traverses the sky each day. To fly from place to place a pilot must know the rules and requirements regarding airspace.

How:

1. **Airspace Classes, Operating Rules, Certification, and Equipment Requirements** AI.II.G.K1

   (Pilot's Handbook of Aeronautical Knowledge; AIM 3-2-1)

   A. Class E Airspace
      i. Definition
         a. Controlled airspace that is not designated A, B, C, or D
         b. Where most of your flying time will be
      ii. Operating Rules and Pilot/Equipment Requirements
         a. Transponder Requirements (91.215)
            - At or above 10,000' MSL
               a Excluding airspace below 2,500' AGL
               b In the contiguous 48 states & D.C.
            - Within 30 miles of a class B airspace primary airport, below 10,000' MSL
            - Within and above all Class C airspace, up to 10,000' MSL
            - Within 10 miles of certain designated airports
               a Excluding airspace which is both outside the Class D surface area and below 1,200' AGL
            - Flying into, within, or across the ADIZ
         b. ADS-B Requirements (91.225(d))
            - At and above 10,000' MSL excluding at and below 2,500' AGL
            - At and above 3,000' MSL over the Gulf of Mexico within 12 nm of the coast
         c. Airspeeds (91.117)
            - No more than 250 knots below 10,000' MSL
            - Below 2,500' AGL within 4 nm of the primary class C, D airspace not over 200 knots

Class E	
VFR Minimum Visibility	Below 10,000' MSL - 3 s.m. Above 10,000' MSL - 5 s.m.
VFR Min Cloud Clearance	Below 10,000' - 500' Below 1000' Above 2,000' Horiz Above 10,000' - 1,000' Below 1,000' Above 1 s.m. Horiz
Min Pilot Qualifications	Student Pilot
VFR Entry and Equipment	As specified: Mode C Transponder & ADS-B
ATC	IFR/IFR Separation VFR advisories on request (permitting)

- Underlying Class B airspace designated for an airport or in a VFR corridor designated through class B airspace not over 200 knots

iii. Pilot Qualifications: Student Pilot

iv. ATC Services

a. There are no communication requirements flying VFR, but you can request traffic advisory services from ATC (Provided on workload-permitting basis)

b. Communication is required when flying IFR in Class E airspace

v. Vertical Limits

a. Unless designated at a lower altitude, Class E Airspace begins at 14,500’ MSL up to, but not including, 18,000’ MSL overlying:
   - The 48 contiguous states including the waters within 12 miles from the coast
   - The District of Columbia
   - Alaska

b. Extends from either the surface or a designated altitude to the overlying or adjacent controlled airspace

vi. Segments of Class E Airspace

a. Class E and the Low Altitude Airway System
   - Connects one navaid to another
     - a VOR to VOR (Victor Airways)
   - Unless otherwise specified, extend from 1,200’ AGL up to, but not including, 18,000’ MSL
     - a Mountainous terrain may have a floor above 1,200’
   - Airways are usually 8 nm wide (4 nm on each side of the centerline)

b. Class E and Airports
   - Extension to a Surface Area
     - a There are Class E airspace areas that serve as extensions to Class B, Class C, and Class D surface areas designated for an airport. Such airspace provides controlled airspace to contain standard instrument approach procedures without imposing a communications requirement on pilots operating VFR
       1. EX: Athens (KAHN) – Class E Surface Area
       2. EX: Washington Wilkes – Class E extension
   - Airspace Used for Transition
     - a Allows IFR traffic to remain in controlled airspace while transitioning between the enroute and airport environments
     - b There are Class E airspace areas beginning at either 700’ or 1,200’ AGL used to transition to/from the terminal or enroute environment

c. When needed for IFR control purposes
   - Enroute Domestic Areas
     - a Provide controlled airspace in those areas where there is a requirement to provide IFR enroute ATC services, but the Federal Airway System is inadequate
     - b Airspace areas that extend upward from a specified altitude as an enroute domestic airspace
   - Offshore Airspace Areas
     - a Provide IFR enroute ATC services
     - b Airspace areas extending upward from a specified altitude to, but not including, 18,000’ MSL to provide controlled airspace beyond 12 miles from the coast of the US

B. Class D Airspace

i. Definition

a. Generally, surface to 2,500 feet above airport elevation

b. Normally 4 nm radius

- Changes depending on needs

c. These airports have a part time operational control tower
   - Class D only when the tower is in operation
   - Otherwise, Class E

d. Configured to the area's operational needs/instrument procedures

ii. Operating Rules and Pilot/Equipment Requirements

a. Pilot Certification
   - No specific certification required

b. Equipment
   - Two-way radio
     a Must establish two-way radio communication with the tower prior to entering the airspace

Class D	
VFR Minimum Visibility	3 Statute Miles
VFR Min Cloud Clearance	500' Below 1000' Above 2,000' Horiz
Min Pilot Qualifications	Student Pilot
VFR Entry and Equipment	Establish Radio Communication
ATC Services	IFR/IFR Separation

C. Class C Airspace

i. Definition

a. Generally, extends from the surface to 4,000' above airport elevation

b. Have an operational control tower, are serviced by a radar approach control, and have a certain number of IFR operations/passenger flights

c. The airspace usually consists of a 5 NM radius core surface area that extends from the surface to 4,000 feet above airport elevation, and a 10 NM radius shelf area that extends from 1,200 feet to 4,000 feet above the airport elevation

ii. Operating Rules and Pilot/Equipment Requirements

a. Pilot Certification
   - No specific certification required

b. Equipment
   - Two-way radio
     a Must establish two-way radio communication prior to entering
   - Operable radar beacon transponder with automatic altitude reporting equipment (Mode C)
   - ADS-B (91.225(d))

Class C	
VFR Minimum Visibility	3 Statute Miles
VFR Min Cloud Clearance	500' Below 1000' Above 2,000' Horiz
Min Pilot Qualifications	Student Pilot
VFR Entry and Equipment	Establish Radio Communication Mode C Transponder ADS-B
ATC Services	IFR/IFR & VFR Separation VFR Traffic advisories (permitting)

Class B	
VFR Minimum Visibility	3 Statute Miles
VFR Min Cloud Clearance	Clear of Clouds
Min Pilot Qualifications	Private Pilot Student w/Endorsement
VFR Entry and Equipment	ATC Clearance Mode C Transponder

	ADS-B
ATC Services	All Aircraft Separation

- a Required in Class C, and above the ceiling and within the lateral boundaries up to 10,000' MSL

D. Class B Airspace
   i. Definition
      a. Generally, the airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports
      b. The configuration of Class B airspace is individually tailored to the needs of a particular area and consists of a surface area and two or more layers
         - Represents an upside-down wedding cake
         - Designed to contain all instrument procedures
   ii. Operating Rules and Pilot/Equipment Requirements
      a. For VFR Operations:
         - At least a Private Pilot Certificate is required
            a Exception: student/recreational/sport pilots with an endorsement
               1. CFRs
                  a. Sport/Recreational Student - FAR 61.94
                  b. Student Pilot - FAR 61.95
                  c. Recreational - FAR 61.101
                  d. Sport- FAR 61.325
               2. AIM 3-2-3b - Exception to the exception: Solo student, sport, and recreational pilot operations are not permitted at any of the following airports:
                  a. Atlanta, GA (Hartsfield)
                  b. Boston, MA (Logan)
                  c. Camp Springs, MD (Andrews Air Force Base)
                  d. Chicago O'Hare
                  e. Dallas, TX (Dallas Fort Worth)
                  f. Los Angeles, CA (LAX)
                  g. Miami, FL (Miami Int)
                  h. Newark, NJ (Liberty)
                  i. JFK, NY
                  j. LaGuardia, NY
                  k. San Francisco, CA (SFO Int)
                  l. Washington DC (Ronal Reagan Airport)
         - ATC Clearance is required before entering
            a Specific clearance to enter Class B airspace is required
         - Must be equipped with an operable two-way radio

Class G	
VFR min Vis & Clearance 1,200' AGL or less	Day: 1 s.m. Clear of Clouds Night: 3 s.m. 500' Below 1,000' Above 2,000' Horiz
VFR Minimum Visibility	Below 10,000' MSL – Day: 1 s.m. Night: 3 s.m. At/Above 10,000 MSL –

	5 s.m.
VFR Min Cloud Clearance	Below 10,000' - 500' Below 1000' Above 2,000' Horiz Above 10,000' – 1,000' Below 1,000' Above 1 s.m. Horiz
Min Pilot Qualifications	Student Pilot
VFR Entry and Equipment	None
ATC Services	VFR advisories on request (permitting)

- 4096-code Mode C transponder
- Mode C Veil
  - a Airspace within 30 nm of a primary Class B airport, from the surface to 10,000' MSL
  - b Must be equipped with automatic pressure altitude reporting equipment having Mode C capability
- ADS-B (91.225(d))
  - a Required in Class B, and above the ceiling and within the lateral boundaries up to 10,000' MSL
  - b From the surface to 10,000' w/in 30 NM of the airports in Part 91 Appendix D Section 1

b. For IFR operations:
- An operable VOR or TACAN receiver or an operable and suitable RNAV system
- An operable radar beacon transponder with automatic altitude reporting equipment
- ADS -B as described above

E. Class A Airspace
i. Generally, the airspace from 18,000 feet MSL up to and including FL600, including the airspace overlying the waters within 12 NM of the coast of the 48 contiguous states and Alaska
ii. Operating Rules and Pilot/Equipment Requirements
a. All operations under IFR, unless otherwise authorized

F. Class G Airspace
i. Definition
a. Uncontrolled Airspace
b. Airspace that has not been designated as Class A, B, C, D, or E
ii. Extends from the surface to the base of overlying Class E airspace
iii. Although ATC has no authority/responsibility, there are VFR minimums which apply to Class G airspace

G. Airspace Summary

Class Airspace	Entry Requirements	Equipment	Minimum Pilot Certificate
A	ATC Clearance	IFR Equipped	Instrument Rating
B	ATC Clearance	Two-way radio Transponder with altitude reporting capability ADS-B	Private – with exception
C	Two-way radio communications prior to entry	Two-way radio Transponder with altitude reporting capability ADS-B	No specific requirement
D	Two-way radio communications prior to entry	Two-way radio	No specific requirement
E	None for VFR	Transponder, as specified ADS-B, as specified	No specific requirement
G	None	No specific requirement	No specific requirement

VFR Weather Minimums Summary (Pilot's Handbook of Aeronautical Knowledge, FAR 91.155)

BASIC VFR WEATHER MINIMUMS		
Airspace	**Flight Visibility**	**Distance from Clouds**
CLASS A	Not Applicable	Not Applicable
CLASS B	3 Statute Miles	Clear of Clouds
CLASS C	3 Statute Miles	500 feet below 1,000 feet above 2,000 feet horizontal
CLASS D	3 Statute Miles	500 feet below 1,000 feet above 2,000 feet horizontal
CLASS E Less than 10,000 feet MSL	3 Statute Miles	500 feet below 1,000 feet above 2,000 feet horizontal
At or above 10,000 feet MSL	5 Statute Miles	1,000 feet below 1,000 feet above 1 mile horizontal
CLASS G 1,200 feet or less above the surface (regardless of MSL altitude) Day, except as provided in section 91.155(b)	1 Statute Mile	Clear of Clouds
Night, except as provided in section 91.155(b)	3 Statute Miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface but less than 10,000 feet MSL Day	1 Statute Mile	500 feet below 1,000 feet above 2,000 feet horizontal
Night	3 Statute Miles	500 feet below 1,000 feet above 2,000 feet horizontal
More than 1,200 feet above the surface and at or above 10,000 feet MSL .... -Exception – 91.155 (b)(2)	5 Statute Miles	1,000 feet below 1,000 feet above 1 mile horizontal

2. Special VFR (FAR 91.157) AI.II.G.K5

A. Clearance to operate under VFR with less than VFR weather minimums
   i. Only in Class B, C, D, or E surface areas, below 10,000' MSL
   ii. Must be requested by the pilot
   iii. Special VFR is on the basis of weather conditions at the airport of intended landing/departure
   iv. Only approved if IFR traffic are not delayed

B. Special VFR may only be conducted
   i. With an ATC clearance
   ii. Clear of clouds
   iii. With at least 1 statute mile flight visibility
   iv. At night (sunset to sunrise):
      a. With an instrument rated pilot and aircraft

C. May not takeoff or land under special VFR unless ground visibility is at least 1 statute mile
   i. If not reported, flight visibility must be at least 1 statute mile
      a. Flight visibility includes the visibility from the flight deck of an aircraft in takeoff position, if:
         - Flight is conducted under Part 91, and
         - The airport is a satellite airport without weather reporting capabilities

D. Special VFR is prohibited at certain airports (mostly large class B airports) shown in Part 91 Appendix D Section 3

3. Special Use Airspace AI.II.G.K3

Special Use airspace exists where activities must be confined because of their nature. In special use airspace, limitations may be placed on aircraft that are not a part of the activities.

A. Prohibited Areas
   i. Airspace within which the flight of aircraft is prohibited
   ii. Established for security or other reasons associated with the national welfare
   iii. Published in the Federal Register and are depicted on aeronautical charts

B. Restricted Areas
   i. Areas where operations are hazardous to nonparticipating aircraft and contain airspace within which the flight of aircraft, while not wholly prohibited, is subject to restrictions
   ii. Can contain unusual, often invisible hazards to aircraft (e.g. artillery firing, aerial gunnery, or guided missiles)
   iii. Penetration without authorization from the using or controlling agency may be extremely hazardous
      a. IFR flights may be authorized to transit the airspace and are routed accordingly
   iv. Restricted areas are depicted on aeronautical charts and are published in the Federal Register

C. Warning Areas
   i. Airspace of defined dimensions, extending from 3 nm outward from the coast of the US, containing activity that may be hazardous to nonparticipating aircraft
      a. The activities may be much the same as those for a restricted area
   ii. The purpose is to warn nonparticipating pilots of the potential danger
   iii. They are depicted on aeronautical charts

D. MOAs (Military Operation Areas)
   i. Consist of airspace with defined vertical and lateral limits established for the purpose of separating certain military training activity from IFR traffic
   ii. IFR traffic may be cleared through a MOA if ATC can maintain IFR separation, otherwise expect a reroute
   iii. There is no restriction against a pilot operating VFR in these areas
      a. A pilot should, although, be alert since training activities may include aerobatic and abrupt maneuvers
   iv. MOAs are depicted on aeronautical charts

E. Alert Areas
   i. Are to advise pilots that a high volume of pilot training or unusual aerial activity is taking place
      a. Exercise caution when transitioning alert areas

        ii. They are depicted on aeronautical charts
    F. Controlled Firing Areas
        i. Contain activities that, if not conducted in a controlled environment, could be hazardous to aircraft
        ii. Activities are suspended when an aircraft might be approaching the area
        iii. No need to chart since they do not cause a nonparticipating aircraft to change its flight path

4. Other Airspace Areas AI.II.G.K3

    A. Special Flight Rules Area (SFRA) (AIM 3-5-7)
        i. Airspace governed by the rules described in Part 93
            a. Normal rules do not necessarily apply – must abide by Part 93 rules
            b. Be familiar with the specific SFRA rules
        ii. Depicted on VFR sectional and terminal area charts as shown here

        iii. Examples include:
            a. Washington, DC (Part 93 Subpart V)
                - Created post 9/11. Pilots must file a special flight rules flight plan, obtain a discrete transponder code, be in contact with ATC, and accomplish specific training
            b. Los Angeles (Part 93 Subpart G)
                - Exceptions to allow VFR traffic to transit the class B airspace without contacting ATC
    B. Local Airport Advisory (LAA)
        i. Area within 10 SM of an airport without an operating control tower, but where an FSS is on the airport
        ii. At these locations the FSS provides a complete local advisory service to arriving and departing aircraft
    C. Military Training Routes (MTR)
        i. Routes used by military aircraft to maintain proficiency in tactical flying
            a. Generally below 10,000' MSL for operation at speeds in excess of 250 knots
        ii. Routes are identified on the sectional chart as IFR (IR), and VFR (VR), followed by a number
            a. MTRs with no segment above 1,500' AGL are identified by four numbers (ex. IR1206, VR1207)
            b. MTRs with one or more segments above 1,500' AGL are identified by 3 numbers (ex. VR407)
    D. Temporary Flight Restrictions (TFRs)
        i. An FDC NOTAM will be issued to designate a TFR
            a. The NOTAM will begin with the phrase "FLIGHT RESTRICTIONS" followed by the location of the temporary restriction, effective time period, area defined in statute miles, and altitudes affected
            b. The NOTAM will also contain the FAA coordination facility and telephone number, the reason for the restriction, and any other information deemed appropriate
        ii. Purposes for establishing a TFR:
            a. Protect persons and property in the air or on the surface from an existing or imminent hazard
            b. Provide a safe environment for the operation of disaster relief aircraft
            c. Prevent an unsafe congestion of sightseeing aircraft above an incident or event, which may generate a high degree of public interest
            d. Protect declared national disasters for humanitarian reasons in Hawaii
            e. Protect the President, VP, or other public figures
            f. Provide a safe environment for space agency operations
        iii. Very important to check these before flying
            a. www.tfr.faa.gov
    E. Parachute Jump Areas
        i. Published in the Chart Supplement
        ii. Frequently used sites are depicted on sectional charts
    F. Published VFR Routes
        i. For transitioning around, under, or through some complex airspace

ii. Also called: VFR flyway, VFR corridor, VFR transition route, and terminal area VFR route
iii. Generally found on VFR terminal area planning charts

G. Terminal Radar Service Areas (TRSA)
   i. Areas where participating pilots can receive additional radar services
   ii. The purpose is to provide separation between all IFR operations and participating VFR traffic
   iii. The primary airport(s) within the TRSA become Class D Airspace
      a. The remaining area of the TRSA overlies other controlled airspace, which is normally Class E Airspace at 700 or 1,200 feet and established to transition to/from the enroute terminal environment
   iv. Depicted on VFR sectionals & terminal area charts with a solid black line and altitudes for each segment
      a. The Class D portion is charted with a blue segmented line
   v. Participation is voluntary, however VFR traffic is encouraged to use the service

H. National Security Areas
   i. Consists of airspace of defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities
   ii. Pilots are requested to voluntarily avoid flying through these depicted areas
   iii. When necessary, flight may be temporarily prohibited

5. VFR Charts

A. Chart Symbology — AI.II.G.K2
   i. Aeronautical Chart User's Guide
      a. Pgs. 17-19: Airspace, Special Use & Other Airspace

B. Chart Updates & Currency — AI.II.G.K4
   i. Terminal Area & Sectional Charts
      a. Updated every 56 days
   ii. Wall Planning Chart
      a. Updated annually
   iii. Information changes rapidly, it is important to check the effective dates on each chart/publication
      a. Always use current editions and discard obsolete charts and publications
      b. Out of date charts may be missing crucial information
         - Changes to airspace, new special airspace, change to procedures, etc.
   iv. To confirm currency, refer to the next scheduled edition date printed on the cover
      a. Use the FAAs Dates of Latest Editions to verify you have the most current edition
      b. Prior to expiration, check NOTAMs and Safety Alerts and Charting Notices for any changes
   v. There is no regulation requiring current charts (FAA FAQ)
      a. It is not FAA policy to violate anyone for having outdated charts in the aircraft
      b. Although, if a pilot is involved in an enforcement investigation and out-of-date charts contributed to the condition, that information may be used in any enforcement action

RM: Various classes & types of airspace — AI.II.G.R1

The lesson as a whole is a discussion on the risks and requirements for each class of airspace

Conclusion:

Brief review of each main point

Overview of the differences based on airspace and traffic

II.H. Navigation Systems & Radar Services

References: Airplane Flying Handbook (FAA-H-8083-3), Instrument Flying Handbook (FAA-H-8083-15), AIM

Objectives	The learner should develop knowledge of the elements related to the navigation systems and radar services provided by ATC as required in the ACS.
Key Elements	1. VOR 2. GPS 3. Radar Services
Elements	1. VOR/VORTAC 2. DME 3. ADF & NDB 4. Satellite Based Navigation 5. Radar Services and Procedures 6. ADS-B Basics 7. Transponder 8. EFBs & Automation 9. Distractions
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner will understand the operation of different navigation systems as well as their use in the airplane. The learner also will understand and be able to utilize the radar services provided by ATC.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Understanding this will greatly decrease your chances of getting lost and provide more services for use.

Overview

Review Objectives and Elements/Key ideas

What

This lesson discusses the different navigation systems in use, as well as radar services provided by ATC when in radar coverage and with established communication.

Why

It is important to understand how the navigation systems function to properly use them. It also is important to know the services provided by ATC to pilots.

How:

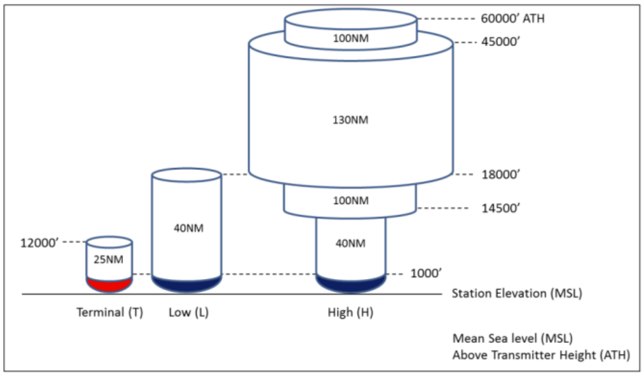
1. **VOR / VORTAC** (Very High Frequency Omnidirectional Range) AI.II.H.K1
   - i. What is it?
     - a. Omni means all
       - An *omni*directional range is a VHF radio transmitting ground station that projects straight line courses (or radials) from the station in *all* directions
         - a It can be visualized from the top as being similar to the spokes from the hub of a wheel
     - b. The radials projected are referenced to magnetic north
       - A radial is defined as a line of magnetic bearing extending outward from the VOR station
       - The accuracy of course alignment with radials is excellent (± 1°)
     - c. VOR ground stations transmit within a VHF frequency band of 108.0 – 117.95 MHz
     - d. VORs are classed according to operational use in 3 classes with varying normal useful ranges:
       - T (Terminal); L (Low Alt); H (High Alt)
     - e. RM: Limitations AI.II.H.R3
       - Radial projection depends on transmitter power
       - VHF signals are subject to line-of-sight restrictions
         - a Range varies in proportion to altitude

Class	Altitudes	Radius (Miles)
T	12,000' and Below	25
L	Below 18,000'	40
H	Below 14,500'	40
H	14,500 – 17,999'	100
H	18,000' – FL 450	130
H	FL 450 – 60,000'	100

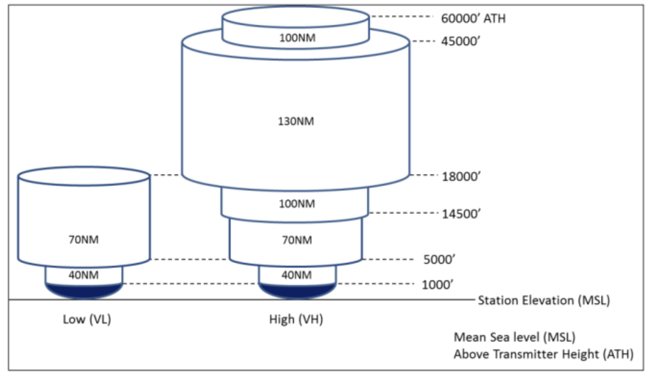
   - ii. VOR MON (Minimum Operating Network)
     - a. National Airspace System is transitioning to performance-based navigation (PBN)
       - Number of VORs is being reduced (going from 896 to 590 by 2030)
       - Two new, larger service volumes will enable near continuous navigation above 5,000' AGL
     - b. Designed to enable aircraft, having lost GPS, to revert to conventional navigation procedures
     - c. New Service Volumes
       - Low: 70 nm from 5,000' to 18,000'

- High: 70 nm from 5,000' to 14,500'

LEGACY SERVICE VOLUMES



NEW SERVICE VOLUMES



iii. Three types of VORS
   a. VOR – The VOR by itself. Provides magnetic bearing information to and from the station
   b. VOR/DME –DME (Distance Measuring Equipment) is installed with the VOR (more info below)
   c. VORTAC – Military tactical air navigations (TACAN) equipment is installed with a VOR
      - DME is always an integral part of a VORTAC

iv. VOR Components
   a. Ground - The VOR station itself; transmits on an assigned frequency
   b. Aircraft - Antenna, Receiver, and VOR navigation instrument
      - Antenna – Picks up the VOR signal
      - Receiver – Processes the signal into navigation information
      - VOR Instrument – Displays the navigation information

         a OBS (Omnibearing Selector, or course selector)
            1. Dial that is rotated to select the desired radial and/or determine the radial on
         b CDI (Course Deviation Indicator) Needle
            1. Indicates position in relation to the selected course/radial
            2. Full scale deflection = 12° or more off course (2° per dot)
         c To/From Indicator
            1. Shows whether the selected course takes the aircraft To or From the VOR
            2. Does not indicate whether the aircraft is currently heading To or From the VOR
         d RM: Flags
            1. OFF flag indicates an unusable/unreliable signal

B. VOR Basics
   i. RM: TIM (Tune, Identify, Monitor) (RM: Loss of a navigation signal) AI.II.H.R4
      a. Tune the VOR frequency
      b. Identify
         - Listen for the station's morse code ID or voice stating the VOR name
         - Look for the VOR 3 letter identifier on the PFD/MFD
         - If the VOR is out of service, the ID is not transmitted (should not be used for navigation)
      c. Monitor the signals/identifier to ensure consistent operation
         - Loss of signal: If the morse code/identifier stops operating, do not use for navigation
   ii. Orientation
      a. Rotate the OBS to center the CDI needle - note the course and the TO or FROM indication

- Only shows direction from the station and has the same indications regardless of heading
- TO indication displays the course to fly to the VOR
- FROM indication displays the radial you're currently on

b. Using a second VOR can provide an exact location at the intersection of the two radials

C. Tracking with the VOR

i. Tune the VOR frequency and check the identifier to verify the desired VOR is being received

ii. Rotate the OBS to center the CDI with a "TO" indication

a. If centered with a "FROM" indication, rotate 180°

iii. Turn to the heading indicated on the VOR azimuth dial or course selector

a. This will track directly to the station in a no wind situation

iv. If there is a crosswind, and heading is maintained, you will drift off course

a. If the crosswind is from the right, the airplane will drift to the left of course

- The CDI will gradually move right

b. To return to the desired radial, the heading must be altered to the right

- As the plane returns, the needle will move back to the center

c. When centered, the plane is on the selected course, and must be crabbed into the wind (right)

- This will establish wind correction (the amount necessary will depend on the wind strength)
  - a Trial and error will establish the necessary heading to maintain the desired track
  - b With a GPS, use the aircraft track to determine heading (eliminates the trial and error)

v. Upon arriving, and passing the VOR station, the TO indication will change to a FROM indication

a. Generally, the same procedures apply for tracking outbound as inbound

- If the intent is to continue on the same heading, the course selector shouldn't be changed
- If tracking outbound on a different course, the new course must be set into the selector
  - a Turn to intercept this course and track the same as previously discussed

vi. Reverse Sensing

a. If flying toward a VOR with a FROM indication, the CDI will indicate opposite the direction it should (this does not apply to an HSI, it will not reverse sense)

- If the plane drifts to the right of course, the needle will show the opposite

b. And vice versa (from a station with a TO indication and opposite drift indications)

D. VOR Checks - FAR 91.171

i. The best assurance of maintaining an accurate VOR receiver is periodic checks and calibrations

a. VOR checks are not mandated for VFR flight

ii. Checks (checkpoints are listed in the Chart Supplement)

a. FAA VOR Test Facility (VOT)

b. Certified Airborne Checkpoints

c. Certified Ground Checkpoints located on airport surfaces

d. Dual VOR check

iii. Verifies the VOR radials the equipment receives are aligned with the radials the station transmits

iv. IFR tolerances required are ± 4° for ground checks and ± 6° for airborne checks

E. VOR Tips

i. Positively identify the station by its code or voice identification

ii. Remember, VOR signals are line-of-sight

iii. When navigating TO, determine the inbound course and use it (Don't reset the course, correct for drift)

iv. When flying TO a station always fly the selected course with a TO indication

v. When flying FROM a station always fly the selected course with a FROM indication

2. Distance Measuring Equipment (DME) AI.II.H.K1

A. Function – provides slant range distance from a station

   i. With VOR and DME, a pilot can determine bearing and distance TO or FROM a station
   ii. Can be used to determine position along a radial or fly a constant distance from a station
B. How it Works
   i. The aircraft DME transmits interrogating RF pulses which a DME antenna on the ground receives
   ii. The signal triggers ground receiver equipment to respond back to the interrogating aircraft
   iii. The aircraft DME measures the elapsed time between the sent signal and the reply signal
      a. The time measurement is converted into NMs from the station
   iv. Some receivers provide ground speed by monitoring the rate of change of position to the station
   v. DME operates on UHF frequencies between 962 MHz and 1213 MHz
C. Components
   i. Ground Equipment - VOR/DME, VORTAC, ILS/DME, and LOC/DME
      a. Uses a "paired frequency" and auto selects the UHF DME frequency associated with the VHF VORTAC frequency the pilot dials in
   ii. Airborne Equipment - Antenna and Receiver
   iii. Pilot Controllable Features
      a. Channel (frequency) Selector: To select the proper channel/frequency desired
      b. On/Off/Volume: Can be used to identify the DME (Morse code plays 1x for every 3-4x VOR)
      c. Mode Switch: Cycles between Distance, GS and time to station
      d. Altitude: Some receivers correct for slant range error
   iv. RM: TIM (Tune, Identify, Monitor) the VOR (RM: Loss of a nav signal) AI.II.H.R4
      a. Do not use if the nav signal is lost
D. RM: Errors & Limitations AI.II.H.R3
   i. DME signals are line-of-sight
   ii. Slant Range Distance
      a. The mileage readout is the straight-line distance from the aircraft to the ground facility
      b. Not the same as the distance from the station to the point on the ground below the aircraft
      c. This error is the smallest at low altitudes and long range
         - Greatest when over the DME station, when it will display altitude above the station
         - Negligible if 1 mile or more away from the facility for each 1,000' above facility elevation

3. Automatic Direction Finder (ADF) & Nondirectional Radio Beacon (NDB) AI.II.H.K1

A. An NDB is a ground-based radio transmitter that transmits radio energy in all directions
   i. The ADF, when used with an NDB, determines the bearing from the aircraft to the station
B. The ADF needle points to the NDB ground station to determine the relative bearing
   i. Relative Bearing: The number of degrees measured clockwise between the heading of the aircraft and the direction from which the bearing is taken
C. Magnetic Heading + Relative Bearing = Magnetic Bearing
   i. Mary Had + Roast Beef= Mary Barfed
   ii. Magnetic Heading: The direction an aircraft is pointed with respect to magnetic North
   iii. Magnetic Bearing: The direction to/from a station measured relative to magnetic North
D. NDB Components
   i. The ground equipment: the NDB (transmits between 190 to 535 KHz)
   ii. Aircraft must be in operational range of the NDB - dependent on the strength of the station
E. ADF Components
   i. The airborne equipment: 2 antennas, a receiver, and the indicator instrument
   ii. Two Antennas
      a. Sense Antenna: (Non-directional) Receives signals nearly equally from all directions
      b. Loop Antenna: (Bidirectional) Receives signals better from two directions
      c. When combined, ADF can receive a signal from all directions except one, resolving directional ambiguity

- iii. Indicator Instrument
  - a. 3 kinds: Fixed card, Movable Card, or the RMI (1 or 2 needles)
  - b. Fixed Card ADF (or relative bearing indicator, RBI) (top picture)
    - Always indicates 0 at the top; Needle indicates RB to the station
    - Pilot must calculate MB based on MH and RB
  - c. Movable Card ADF (middle picture)
    - Automatically rotates to display aircraft heading
    - Head of the needle indicates the MB to the station
    - The tail indicates MB from the station
    - Instrument provides MB, pilot doesn't have to calculate it
  - d. RMI (bottom picture)
    - Automatically rotates to display aircraft heading
    - Can have two needles which can be used for navigation information from either ADF or VOR receivers
    - ADF needle:
      - a Head indicates the MB To the station
      - b Tail indicates the MB From the station
    - VOR needle: Indicates location radially with respect to the station
      - a Head of needle points the bearing TO the station
      - b Tail points to the radial the aircraft is currently on/crossing

F. RM: Limitations AI.II.H.R3
- i. Lighting, precipitation, static, etc. result in erroneous bearing information
- ii. At night, NDBs are vulnerable to interference from distant stations
- iii. Noisy identification usually occurs when the ADF needle is erratic
  - a. Voice, music, or erroneous identification will usually be heard when a steady false bearing is displayed
- iv. ADF receivers do not have a flag to warn the pilot of erroneous bearing information

G. Using the NDB
- i. RM: TIM (Tune, Identify, Monitor) (RM: Loss of a navigation signal) AI.II.H.R4
  - a. Transmit 3-letter identification code
  - b. Very important since there is not a flag to warn the pilot of erroneous information
- ii. Orientation (Fixed Card ADF)
  - a. The ADF needle points TO the station, regardless of heading or position
    - Therefore, the RB shown is the angular relationship between heading and the station measured clockwise from the nose of the aircraft
  - b. Visualize the ADF dial in terms of the longitudinal axis
    - When the needle points to 0°, the nose points directly to the station
    - With the pointer on 210°, the station is 30° to the left of the tail
  - c. The RB must be related to aircraft heading to determine direction TO/FROM
    - Magnetic Heading + Relative Bearing = Magnetic Bearing
- iii. Movable Card/RMI
  - a. Turn toward the head of the needle indicating the MB to the station
  - b. Adjust for wind to maintain the desired course

4. Satellite Based Navigation AI.II.H.K2

A. GPS (Global Positioning System)
- i. 3 major elements
  - a. Space Segment
    - Composed of a constellation of 31 satellites approximately 11,000 NM above the earth

      a The US is committed to maintain 24 operational satellites 95% of the time
      b Arranged so at any time, 5 are in view to any receiver (4 are necessary for operation)
      c Each satellite orbits the Earth in approximately 12 hours
      d Equipped with highly stable atomic clocks and transmit a unique code/nav message
    - The satellites broadcast in the UHF range (meaning they are virtually unaffected by weather), although they are subjected to line-of-sight references
      a Must be above the horizon (as seen by the antenna) to be usable for navigation
  b. Control Segment
    - Consists of a master control station, 5 monitoring stations, and 3 ground antennas
    - Monitoring stations/ground antennas are distributed around the earth
      a Updates/corrections are uplinked as the satellites pass over the ground antennas
  c. User Segment
    - Consists of all components associated with the GPS receiver
      a Range from portable, hand-held receivers to those permanently installed in the plane
    - The receiver utilizes the signals from the satellites to provide:
      a Positioning, velocity, and precise timing to the user

ii. Solving for Location
  a. The receiver utilizes the signals of at least 4 of the best positioned satellites to yield a 3D fix
    - 3D - Latitude, longitude, and altitude
    - Using calculated distance/position info from the satellite, the receiver calculates its location

iii. Navigating
  a. VFR navigation with GPS can be as simple as selecting a destination and tracking the course
  b. Course deviation is linear - there is no increase in sensitivity when approaching a waypoint
  c. It can be very tempting to rely exclusively on GPS, but never rely on one means of navigation

iv. RM: RAIM (Receiver Autonomous Integrity Monitoring) AI.II.H.R4
(RM: Loss of navigation signal & Limitations)
  a. How the GPS verifies the integrity of the signals received from the satellites
    - Without RAIM, there is no assurance of GPS accuracy
  b. Requires at least 5 satellites in view (or 4 satellites and a barometric altimeter)
    - At least one satellite, in addition to those required for navigation
    - Some receivers can use a 6^{th} satellite to isolate and remove a corrupt satellite
  c. RAIM Messages (generally, two types)
    - Not enough satellites available to provide RAIM integrity monitoring
    - RAIM has detected a potential error exceeding the limit for the phase of flight

v. RM: GPS for VFR (RM: Limitations) AI.II.H.R3
  a. In VFR operations, GPS receivers can vary between full IFR installation to handheld receivers
    - Many have no RAIM capability & antenna location is based on convenience instead of performance
    - Loss of signal coupled with no RAIM capability could present erroneous with no indications
    - Limitations of the individual installation must be understood
  b. Database Currency
    - AIM 1-1-1b3(b): Databases must be maintained to the current update for IFR operations
      a No requirements exist for VFR ops; however it is always a good idea to keep a current database
    - Violations
      a It is not FAA policy to initiate enforcement action against a pilot for having an expired database
      b However, if involved in an enforcement investigation and there is evidence an out-of-date database contributed to the situation, that information could be used in any enforcement action
      c Bottom line, use current databases

B. WAAS (basically augmented GPS, to the point it may be used for precision approaches)
   i. Designed to improve the accuracy, integrity, and availability of GPS signals
      a. Integrity is improved through real-time monitoring of the satellites
         - Can provide warnings when the signal is providing misleading data that could be hazardous
         - Extremely small chance an error would go undetected – equivalent of no more than 3 seconds of bad data per year
      b. Accuracy is improved by providing corrections to the satellites to reduce errors
         - A network of ground-based stations measures small variations in satellite signals
         - Measurements are routed to a master station
         - Master station sends the correction messages to the satellites which broadcast the message
         - Measurements have shown it can provide better than 1 meter laterally & 1.5 meters vertically
C. LAAS (now more commonly referred to as GBAS – Ground Based Augmentation System)
   i. Like WAAS, but with more ground augmentation
   ii. All-weather aircraft landing system based on real-time differential correction of the GPS signal.
   iii. Local reference receivers located around the airport send data to a central location at the airport
      a. Data is used to formulate a correction message, which is then transmitted to users via a VHF Data Link
   iv. Information is used to correct GPS signals, and provide an ILS-style display while flying a precision approach

5. Radar Assistance (AIM 4-1-17 & 18) AI.II.H.K3

A. Radar equipped ATC facilities provide radar assistance & navigation services (vectors) to VFR aircraft, provided:
   i. You can communicate with ATC, are within radar coverage, and can be radar identified
      a. Requires VHF radio and transponder (as well as any other airspace required equipment)
B. Limitations
   i. Based on controller discretion
      a. Radar limitations, traffic volume, controller workload/frequency congestion may prevent the service
      b. Controller's reasoning for not providing the service is not subject to question or necessary to explain
   ii. Guidance information is advisory and responsibility for safe flying remains with the pilot
   iii. Cannot determine if flight into IMC will results from their instructions
   iv. Can only work with the information and aircraft on hand
      a. Limited information on aircraft that are not participating and where they're going/what they're doing
C. Other services include:
   i. Basic Radar Service – Safety alerts, traffic advisories, limited radar vectoring (workload permitting), and sequencing at certain locations
   ii. TRSA Service - Radar sequencing and separation for VFR aircraft in a TRSA
   iii. Class C services - Separation between IFR/VFR and sequencing of VFR traffic to the airport
   iv. Class B services - Separation based on IFR, VFR and/or weight and sequencing VFR arrivals

6. ADS-B (Automatic Dependent Surveillance – Broadcast) Basics AI.II.H.K4

A. What is it?
   i. Foundation for NextGen moving from ground radar to satellites
      a. More precise tracking: Broadcasts every second vs a radar sweep every 5-12 seconds
      b. Radar waves are limited to line-of-sight and installation sites
         - ADS-B combines ground stations/satellites for better visibility regardless of terrain/obstacles
         - ADS-B ground stations are much easier to install than radars
   ii. ADS-B
      a. Automatic: Automatically transmits information
      b. Dependent: Position/velocity are derived from GPS/FMS
      c. Surveillance: Allows 3D position and identification
      d. Broadcast: Transmits the information to anyone with appropriate receiving equipment

- iii. ADS-B Out
  - a. Broadcasts GPS location, altitude, ground speed and more to ground stations/other aircraft
- iv. ADS-B In
  - a. General
    - Pilots can see what controllers see in the air as well as on the ground (taxiways/runways)
    - Provides weather and traffic position information directly to the flight deck
      - a Graphical weather displays, advisories (NOTAMs, weather, terrain, TFRs, etc.)
  - b. FIS-B (Flight Information Service Broadcast – available on 978 MHz UAT equipment)
    - Like XM weather, but more information
    - Textual/graphical weather products/flight info (SIGMET, PIREP, turbulence, lightning, etc.)
  - c. TIS-B (Traffic Information Service Broadcast – available to 1090ES and UAT equipment users)
    - Provides traffic information on all transponder-based aircraft in the vicinity of the ADS-B

B. Who Needs it?

- i. FAR 91.225 – ADS-B OUT is required in:
  - a. Class A, B, and C airspace
    - Above the ceiling of Class B and C airspace up to 10,000' MSL
  - b. Class E airspace at and above 10,000' MSL excluding at and below 2,500' AGL
    - At and above 3,000' MSL over the Gulf of Mexico within 12 nm of the coast
- ii. ADS-B IN is voluntary
- iii. ADS-B Deviation Authorization
  - a. ADAPT, or ADS-B Deviation Authorization Preflight Tool – Must meet the following:
    - Must be equipped with operational transponder and altitude encoder
    - Submit no more than 24 hours before flight and no less than 1 hour before flight

C. What do I need?

- i. Straight from the FAA: Equip ADS-B Installation
- ii. FAR 91.227 – ADS-B Out Equipment Performance Requirements

7. Transponder AI.II.H.K4

A. Modes

- i. A: Transmits 4-digit code that identifies an aircraft and its position
- ii. C: Mode A + ATC can see the aircraft's altitude
- iii. S: Transmits a variety of information to ATC & other aircraft
  - a. Unique ICAO address (assigned to each aircraft)
  - b. Heading, speed, other flight related data
  - c. Integral to TCAS (Traffic Collision Avoidance System) and ADS-B

B. See lesson II.G. National Airspace System for transponder requirements

8. RM: EFBs & Automation (Navigation & Flight Systems) AI.II.H.R1, AI.II.H.R5

A. Pilots are responsible for proper use of an EFB and installed avionics

- i. Pilots may be evaluated on the use and interpretation of an EFB or installed avionics

B. Although not legally required, always maintain current EFB charts and publications

C. Understand the abilities and limitations of the system(s) on your aircraft & how they work together

- i. Always monitor and ensure the system is doing what you intend, when you intend it to
- ii. Ensure the autoflight system is properly programmed to fly off the appropriate navigation source
- iii. A lack of familiarity can be a tremendous distraction in the cockpit and pull focus away from flying/scanning

9. RM: Distractions (Task Prioritization, Loss of SA, Disorientation) AI.II.H.R2

D. Distractions

- i. Distractions can be dangerous
  - a. Navigation systems, especially GPS/moving maps, can consume the pilot's attention

ii. Fly first! Aviate, Navigate, Communicate

E. Situational awareness (SA)
   i. Navigation systems and radar services can be huge for situational awareness
   ii. Don't be overdependent on a single system (like the GPS), if the GPS/VOR fails, have a backup
   iii. If SA is lost, admit it, and find a way to regain

F. Task Management
   i. Divide attention between flying/navigating, scanning, and communicating
      a. No one responsibility should take your full attention full more than a short period
   ii. Recognize when you are getting behind and find a way to catch up

Conclusion:

Brief review of the main points

When navigating with a VOR and you wish to head toward the station ensure the flag indicates "TO" and follow the indicated heading. When it is necessary to track away from the station, ensure the flag indicates "FROM" and follow the heading indicated. Failing to do this could result in reverse sensing (not applicable to an HSI). GPS is a satellite-based navigation system. WAAS and LAAS are also satellite based navigation systems, but they augment the GPS system with ground-based stations allowing for more precise location information as well as vertical guidance. The radar services provided by ATC can be very helpful in almost any flight.

II.I. Navigation and Flight Planning

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives	The learner should develop knowledge of the elements related to navigation and flight planning as required in the applicable tasks in the ACS.
Key Elements	1. Time, Distance, and Fuel Calculations 2. Navigation 3. Lost Procedures
Elements	1. Terms 2. Charts & Chart Supplement 3. Navigation 4. Flight Planning 5. VFR Flight Plan 6. Weather Check & Decision Making 7. GPS Navigation 8. Planned Calculations versus Actual Results 9. Diversion to an Alternate 10. Lost Procedures 11. Flight Following & Intercept Procedures
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Aeronautical Charts (Sectional and Terminal Area Chart) 4. Navigation Log 5. Flight Computer
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can properly and confidently plan and execute a cross country flight to any chosen destination. The learner also understands the procedures for diversions and lost situations.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This is what leads to using everything you have learned so far and flying yourself somewhere!

Overview

Review Objectives and Elements/Key ideas

What

Navigation and flight planning is the process of planning and executing cross country flights, and includes procedures for situations that may arise during flight (diversions, lost procedures, using flight following & intercepts)

Why

This information will make planning flights easier and more organized. Proper flight planning is integral to safe flying between airports.

How:

1. **Terms**
   A. Navigation Terminology
      i. True North – Points directly to the geographic north pol
      ii. Magnetic North – Aligns with Earth's magnetic field and points directly to the magnetic north pole
      iii. Variation – The angular difference between true north and magnetic north; isogonic lines on charts
      iv. True Course – The direction of flight as measured on a chart clockwise from true North
      v. True Heading – The direction the longitudinal axis of the airplane points with respect to true North
         a. True heading equals true course plus or minus any wind correction angle
      vi. Magnetic Course – True course corrected for magnetic variation
      vii. Magnetic Heading – Magnetic Course corrected for wind (direction and speed)
      viii. Compass Heading – Aircraft heading read from the compass
         a. Derived by applying correction factors for variation, deviation, and wind to your true course
      ix. Deviation – Compass error due to magnetic disturbances from electrical/metal parts in the plane
         a. The correction for this is displayed on a compass correction card near the magnetic compass
   B. Atmospheric Terminology
      i. Standard Pressure – 29.92" Hg (at sea level)
      ii. Standard Temperature – 15^{o} C / 59^{o}F (at sea level)
   C. Altitude Terminology
      i. Indicated Alt –Altitude read directly from the altimeter after it's set to the current altimeter setting
      ii. Pressure Alt – Height above the standard pressure level of 29.92 in Hg - $1{,}000(29.92 - Alt) + Elev$
         a. Obtained by setting 29.92 in the barometric pressure window and reading the altimeter
      iii. Density Alt – Pressure altitude corrected for nonstandard temperatures - $120(°C - 15°C) + PA$
         a. The equation above is not exact
         b. Directly related to an aircraft's takeoff, climb, and landing performance
      iv. True Altitude – The true vertical distance of the aircraft above sea level
         a. Airport, terrain, and obstacle elevations found on aeronautical charts are true altitudes
      v. Absolute Altitude – The vertical distance of the aircraft above the surface of the earth (AGL)
   D. Airspeed Terminology
      i. Indicated (IAS) – The speed of an aircraft as shown on the airspeed Indicator

ii. Calibrated (CAS) – Indicated airspeed of an aircraft, corrected for installation and instrument errors
iii. Equivalent (EAS) – CAS corrected for adiabatic compressible flow for the altitude
iv. True (TAS)– The speed at which an aircraft is moving relative to the surrounding air
  a. Equal to CAS corrected for density altitude
v. Groundspeed (GS) – The speed of the aircraft in relation to the ground
  a. Equal to TAS corrected for wind(tailwind/headwind)

2. Aeronautical Charts & Chart Supplement

A. Charts AI.II.I.K15
  i. The roadmap for a pilot flying VFR
    a. Provide info which allows pilots to track their position and to enhance safety
      - Shows things such as: terrain/elevation, VFR checkpoints, water, cities, airports, power lines, obstacles, airspace, airways, navaids, etc.
    b. FAA Aeronautical Chart User's Guide
    c. Chart Downloads
  ii. Sectional Charts (Most commonly used by pilots)
    a. Information provided:
      - Airport data, navigational aids, airspace, and topography
    b. Scale is 1:500,000 (1" = 6.86 NM)
    c. Revised every 56 days
  iii. VFR Terminal Area Charts
    a. Helpful when flying in or near Class B airspace
    b. They provide a more detailed display of topographical info
    c. Scale is 1:250,000 (1" = 3.43 NM)
    d. Revised every 56 days
  iv. VFR Wall Planning Chart
    a. Designed for VFR preflight planning
    b. Provides aeronautical and topographic information of the conterminous US
      - Airports, navaids, Class B airspace, Special use airspace
    c. Scale is 1:3,100,000 (1" = 43 NM)
    d. Revised annually
  v. Proper and Current Aeronautical Charts
    a. Information changes rapidly, it is important to check the effective dates on each chart/publication
      - Always use current editions and discard obsolete charts and publications
      - Out of date charts may be missing crucial information
        a Frequency changes, airport/runway changes, obstacles, etc.
    b. To confirm currency, refer to the next scheduled edition date printed on the cover
    c. Also check NOTAMs for important updates

B. Chart Supplement
  i. Essential to planning
    a. FAA Chart Supplement description
    b. Digital Chart Supplements
  ii. Provides the most comprehensive information on a given airport
    a. Detailed runway information, procedures, frequencies, hours of operation, lighting, services, and more
    b. Reference all potential airports during planning (departure, arrival, alternates)
    c. Also provides, VFR waypoints, VOR checkpoints, chart bulletins, LAHSO operations, parachute jump areas, special notices and FAA, NWS, and facility phone numbers

3. Navigation AI.II.I.K10

A. Pilotage – Navigation by reference to landmarks or checkpoints

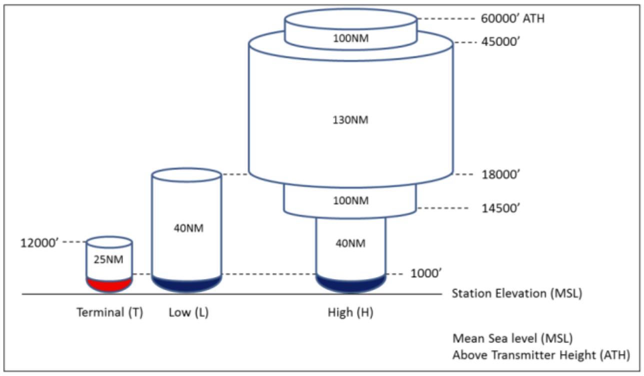
i. A method of navigation that can be used on any course with adequate checkpoints, but is more commonly used in conjunction with dead reckoning and VFR radio navigation
    a. It becomes difficult in areas lacking prominent landmarks or in low visibility
ii. The checkpoints used should be prominent features common to the area of flight
    a. Choose checkpoints that can be readily identified by other features such as roads, rivers, railroad tracks, lakes, and power lines
        - Roads shown are usually the most traveled/easily visible from the sky
            a New roads and structures are constantly being built and may not be on the chart
iii. If possible, select features that will make useful boundaries on each side of the course
    a. Keep from drifting too far off course be referring to, and not crossing selected brackets
iv. Never place complete reliance on any single checkpoint, choose ample checkpoints
    a. If one is missed, look for the next one while maintaining the necessary heading
    b. Turn based on time if the checkpoint is not in sight, do not continue blindly

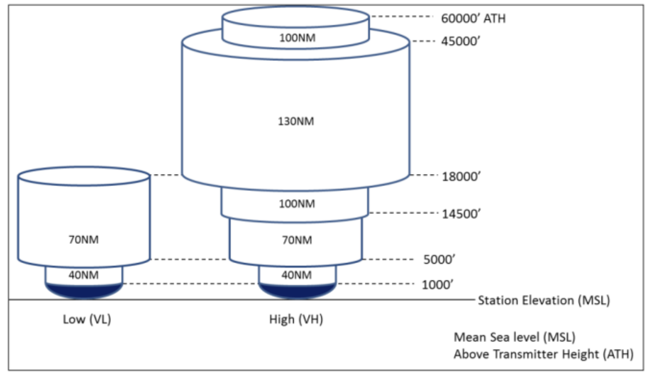
B. Dead Reckoning – Navigation solely by computations based on time, airspeed, distance, and direction
i. The products derived from these variables, when adjusted by wind speed and velocity, are heading and ground speed (GS)
    a. The predicted heading will guide the airplane along the intended path and the GS will establish the time to arrive at each checkpoint and destination

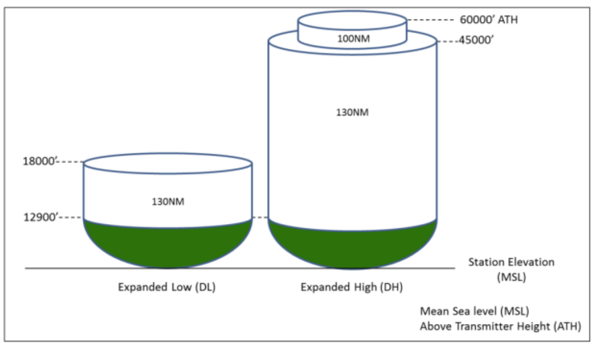
C. Radio Navigation – Navigation by which a predetermined flight path is followed
i. There are three primary navigation systems available: VOR, NDB, and GPS
    a. Aircraft equipment and preference will dictate which system to use
        - GPS and VOR are the most common
        - NDBs are almost non-existent
    b. LORAN-C used to be a navigation source but was discontinued in 2010/2011
    c. For more detailed information, see II.L. Navigation Systems and Radar Services

D. VOR Minimum Operating Network (VOR MON)
i. National Airspace System is transitioning to performance-based navigation (PBN)
    a. Number of VORs is being reduced (going from 896 to 590 by 2030)
    b. Two new, larger service volumes will still enable near continuous navigation above 5,000’ AGL
        - Coverage will exist lower, but may not be guaranteed
ii. Designed to enable aircraft, having lost GPS, to use conventional navigation procedures
    a. Can use VOR station to station nav to reach a MON airport and fly a conventional approach
        - ILS, LOC, VOR, etc.
        - MON airport assured within 100 nm
iii. New VOR/DME Service Volumes
    a. Low VOR: 70 nm from 5,000’ to 18,000’

LEGACY SERVICE VOLUMES | **NEW MON SERVICE VOLUMES**



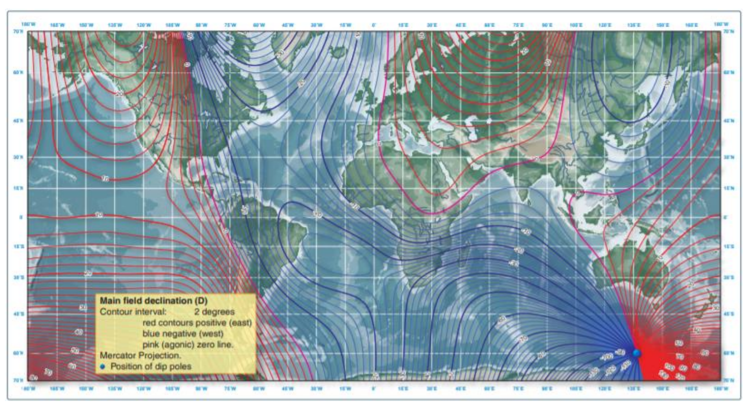




b. High VOR: 70 nm from 5,000' to 14,500'

E. Ideally, pilotage, dead reckoning, and radio navigation should be used together
   i. Exceptions include over water, featureless terrain at night, etc. (no pilotage)
   ii. Heading and GS are constantly monitored and corrected by pilotage as observed from checkpoints
   iii. Radio navigation further confirms the course flown

F. Magnetic Compass Errors AI.II.I.K9
   i. Variation
      a. Caused by the difference in the locations of the magnetic and geographic north pole
         - The magnetic north pole is not collocated with the geographic north pole
         - They're approximately 1300 miles apart
      b. Isogonic Lines: Lines used to connect points with the same magnetic variation

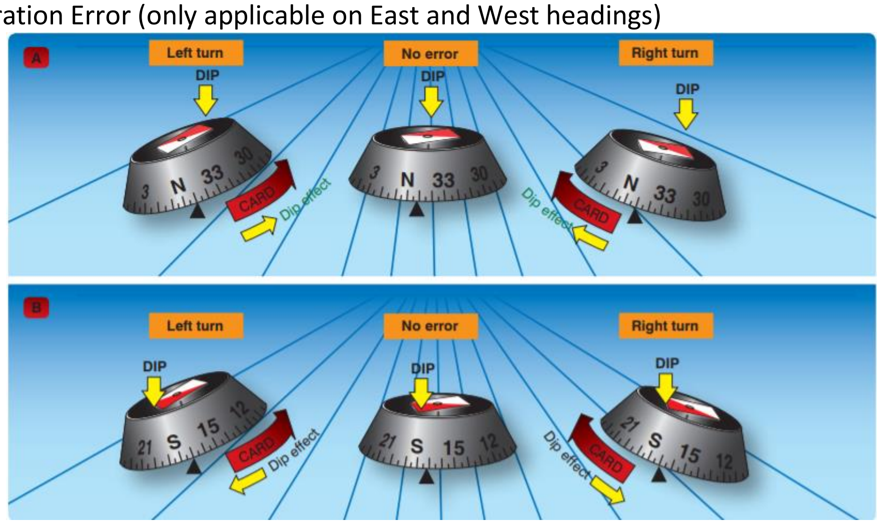


      c. Agonic Line: The line along which the two poles are aligned, and there is no variation
   ii. Deviation
      a. Caused by local magnetic fields within the aircraft
         - Not affected by geographic location (like variation)
      b. Degrees of deviation is shown on a compass correction card
         - Different on each heading; can be minimized by "swinging the compass"
      c. Compensator units (magnets that compensate for deviation) can also help
   iii. Finding the Compass Course – True Course corrected for Variation and Deviation

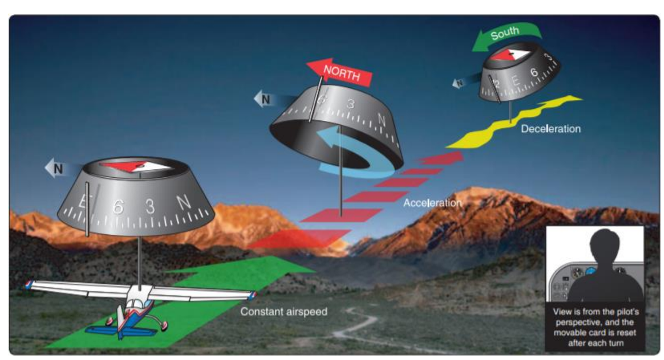
- a. True Course ± Variation = Magnetic Course; Magnetic Course ± Deviation = Compass Course
- b. Remember: East is Least, West is Best
    - East: Subtract variation from true course; West: Add variation to true course

iv. Dip Errors

- a. What's Going On
    - Lines of magnetic flux leave the Earth at the magnetic N pole/enter at magnetic S pole
        - a At both poles the lines are perpendicular to the surface
        - b Over the equator the lines are parallel to the surface
    - Magnets align with these fields and near the poles they dip/tilt the float and card
- b. Northerly and Southerly Turning Errors (basically, the compass pulls toward the North)
    - Starting a turn from a Southerly heading (turning to a Northerly direction):
        - a Compass Leads – initially shows a more aggressive turn in the same direction
        - b As the aircraft banks, the compass card tilts with it, and the magnetic field pulls the card in the direction of the turn (toward the North)
        - c Undershoot Northerly headings to compensate (30º- N; 20º- 030/330; 10º- 060/300)
    - Starting a turn from a Northerly heading (turning to a Southerly direction):
        - a Compass Lags – initially shows a turn in the opposite direction
        - b As the aircraft banks the compass card tilts with it, and the magnetic field pulls the card opposite the direction of turn (back toward the North)
        - c Overshoot Southerly headings to compensate (30º- S; 20º- 150/210; 10º- 120/240)
    - *Remember*: Undershoot North, Overshoot South (no compensation needed for E/W)
- c. Acceleration Error (only applicable on East and West headings)



- Due to the pendulous-type mounting, the aft end of the compass tilts up when accelerating and down when decelerating
- On an E or W heading, acceleration appears as a turn to the North, and deceleration indicates a turn toward the South
- *Remember*: ANDS – Accelerate North, Decelerate South



v. Oscillation Error

- a. A combination of all the other errors as well as the movement of the plane
    - It results in the compass card swinging back and forth around the heading being flown

b. Use the average indication

4. Flight Planning

Note: Per the ACS, preparation, presentation, and explanation of a computer-generated flight plan is acceptable

A. The flight log provides the pilot an organized, point by point plan of the flight
   - i. The pilot can monitor the progress of the planned flight vs the actual conditions and adjust course, fuel burn, time calculations, etc. to ensure a safe, timely arrival or to realize the need for a diversion (for example, due to stronger headwinds and a higher fuel requirement)
   - ii. Necessary frequencies, waypoints, headings, etc. are in order and easy to find for the pilot's use

B. Plotting a Course
   - i. First, draw the route AI.II.I.K1
     - a. Draw a line (or lines depending on your course) from Point A to Point B
       - If the route is direct, the course will consist of a single straight line
       - If not, it will consist of 2 or more straight line segments
         - a For example, a VOR station which is off the direct route but will make navigating easier
     - b. Always consider terrain, airspace, navigation capabilities, performance, etc. when choosing the route
       - Ensure you meet and understand the requirements for different classes and types of airspace
     - c. Note alternate airports & the type of terrain in case of an emergency landing (water, mountains, etc.)
       - Have a plan in case of an emergency at different points of the flight
   - ii. Decide what altitude you will fly based on the direction of flight, terrain, fuel, etc. AI.II.I.K2
     - a. FAR 91.159
       - When more than 3,000' above the surface, and below 18000' MSL:
         - a On a magnetic course of 0-179°, fly any odd thousand-foot MSL altitude + 500'
           - 1. 3,500, 7,500, 13,500, etc.
         - b On a magnetic course of 180-359°, fly any even thousand-foot MSL altitude + 500'
           - 1. 2,500, 8,500, 16,500, etc.
       - When operating above 18,000' (Class A airspace), maintain the altitude/flight level assigned by ATC

     - b. Factors Affecting Altitude
       - Terrain
         - a Ensure the required performance to safely clear terrain
         - b Reference Maximum Elevation Figures (depicted, right)
         - c Avoid particularly rugged terrain, if possible
       - Glide Distance
         - a Ensure the ability to glide to an alternate airport or safe landing area
           - 1. Especially important when over water – ensure the ability to glide back to land
       - Weather & Wind
         - a Weather
           - 1. Cloud Cover & Storms
             - a. Navigate over or around storms, as possible (VFR permitting)
             - b. This can change planning the day of a trip – adjust as required for safety
           - 2. Icing
             - a. If flying in rainy/hazy conditions check the freezing level to avoid icing
         - b Wind varies with altitude
           - 1. Check winds aloft to find the most favorable winds (tailwind)
       - Unique Factors
         - a Analyze the flight for any other unusual factors that will affect the altitude flown
       - Combine all factors with the FAR requirements to choose the most beneficial altitude

C. Checkpoints – Recognizable points along your route of flight used to maintain your course AI.II.I.K3
   i. Top of Climb (TOC) AI.II.I.K5a
      a. First, map out your top of climb waypoint, this will provide a reference for the time, and distance using a climb power setting (increased fuel burn)
      b. Based on Rate of Climb information and cruising altitude, calculate the distance to the top of climb
         - Rate of Climb can be calculated in the AFM (ex. 1,000 fpm)
         - Altitude to climb: Cruise altitude minus Airport Elevation (ex. 6,500' -500' = 6,000' to climb)
         - 6,000' to climb at 1,000 fpm = 6 minutes of climbing
         - Use your groundspeed (GS) in the climb (TAS adjusted for wind) to compute the distance it will take to climb to 6,500' MSL
            a Ex. If your GS is 90 knots in the climb, then it will take 9 nm to reach your altitude
               1. 6 min/60 min = 1/10 of an hour of climbing
               2. Every hour the aircraft travels 90 nm, therefore (90 nm/hr.)(1/10 hr.) = 9 nm
      c. Label the TOC on your course 9 nm from the departure airport
         - Attempt to find a checkpoint that corresponds with the TOC
            a The visual checkpoint may not coincide perfectly with the 9 nm point
            b Be creative, for example, abeam a lake, or portion of a highway
   ii. Top of Descent (TOD) AI.II.I.K5a
      a. Second, map out your top of descent waypoint, this will provide a point to start the descent into the terminal area of your destination
      b. Based on Rate of Descent info and cruising altitude
         - Rate of Descent is up to you and your aircraft (we'll use 1,000 fpm as an example)
         - Altitude to descend (Cruising altitude – Airport Elevation)
            a Ex. 6,500' – 1,200' = 5,300' to descend
            b Note: Rather than making the calculation based on descending to the airport elevation (the ground) it may be more beneficial to use pattern altitude instead
         - Time to descend: 5,300' to descend at 1,000 fpm
            a How many minutes will it take to descend 5,300' when you're descending at 1,000 fpm
               1. 5,300/1,000 = 5.3 minutes
         - Distance to descend
            a Using your ground speed calculate how far you will travel in 5.3 minutes
            b If Ground speed = 150 kts, then you need to start your descent 13-14 nm from the airport
               1. 5.3 minutes/60 minutes = 0.088 hours (convert minutes to hours)
               2. 0.088 hours x 150 kts/hr. = 13.25 nm
               3. Therefore, plan to start your descent about 14 nm from the airport
      c. Mark this point (14 nm before your destination) on the course
         - Find a visual checkpoint nearby to remind you to start your descent
   iii. Find additional checkpoints along the route to bridge the gap between the TOC and TOD
      a. These will be used to ensure you maintain the desired route (don't get lost)
      b. Distance between checkpoints can vary based on the trip and personal comfort
         - A checkpoint every 10-25 nm is good to prevent getting lost
         - Don't overburden yourself
      c. Checkpoints should be easy to locate points like large towns, lakes and rivers, or combinations of recognizable points like towns with an airport, or a network of highways or railroads, geographic features like mountain ranges are also helpful
         - Normally choose towns indicated by splashes of yellow on the chart
         - Do not choose towns signified by a small circle - they may be only a half-dozen homes

a In isolated areas, although, this can be a prominent, usable checkpoint

iv. Record your TOC, TOD, and additional checkpoints on your Nav Log

D. Fuel Stops & Requirements AI.II.I.K5c

i. FAR 91.151 requires fuel to fly to the point of intended landing and, at normal cruise power, fly for at least:
   a. 30 min during the day, or 45 min during the night

ii. Longer flights will have to incorporate multiple legs for fuel stops
   a. Create a separate nav log for each leg of the flight

iii. More details on fuel planning below

E. Completing the Nav Log AI.II.I.K5a, AI.II.I.K5b

i. Chooser a power setting AI.II.I.K4
   a. Use the chart provided in the POH based on desired speed, fuel burn, altitude, etc.

ii. Based on the power setting, find the True Airspeed, and record it on your Nav Log
   a. Use the chart provided in the aircraft POH

iii. Now that the course is drawn and the checkpoints are marked, find the distance between each of the checkpoints by measuring the course on the map
   a. Input these distances in the Nav Log

iv. Next, find the true course for each leg of the flight plan
   a. True Course (TC) – Direction of the line connecting two points drawn on the chart and measured clockwise in degrees from True North
      - North is always straight up when measuring true course
      - Use your plotter to find the True Course

v. Adjust True Course for wind to get True Heading
   a. On the back of the flight computer, calculate the Wind Correction Angle and add/subtract it to/from the True Course to get True Heading
      - Add West, subtract East corrections (Memory Aid: East is least, West is best)
      - Also make a note of the Ground Speed for each leg of the flight on the Nav Log

vi. Finally, adjust the True Heading to obtain the Magnetic Heading
   a. Magnetic Heading - Magnetic variation is applied to True Heading
      - Using the isogonic lines on the sectional, add or subtract the necessary number of degrees to find the magnetic heading required to maintain your course

vii. If necessary, get Compass Heading by adjusting for Deviation with the correction card near the compass

viii. At this point your Nav Log should have all the checkpoints listed, each with a distance, a True Course, True Heading, Magnetic Heading, Compass Heading, as well as an altitude and Ground Speed

ix. Next is the Time and Distance Information
   a. Since you already have the Distance and Ground Speed between each point, calculate the estimated amount of time for each leg
      - Distance = Rate x Time, so Time = Distance/Rate (or Ground Speed)
   b. Based on expected departure time, you can calculate an expected arrival time
      - Convert to UTC

UTC CONVERSION Add to local time:	Pacific Standard: 8 hrs Pacific Daylight: 7 hrs	Mountain Standard: 7 hrs Mountain Daylight: 6 hrs	Central Standard: 6 hrs Central Daylight: 5 hrs	Eastern Standard: 5 hrs Eastern Daylight: 4 hrs

   c. Finally, use the Time for each leg to find the fuel burn for each leg
      - Using the POH find your fuel burn for Climb, Cruise, and Descent
         a It will be shown in Gallons per hour
         b Convert your time for each leg into hours and then find the gallons burned per leg
            1. This can be done using the flight computer or a calculator
            2. For example, a 10-minute leg at 15 gallons per hour

a. Convert minutes to hours (10 min / 60 min per hour = .167 hours)
b. Convert 15 gallons per hour to the number of gallons used in .167 hours
    i. 15 * 0.167 = 2.5 gallons

- RM: Fuel Planning Considerations AI.II.I.R6
    a Ensure fuel required for the trip plus an adequate reserve is available
        1. Adequate reserve is a minimum of the FAR requirements
            a. Personal minimums may be higher
        2. Account for engine start & taxi
        3. Ensure fuel will allow deviation to an alternate airport/landing with reserves
    b Rate of fuel burn depends on many factors
        1. Engine condition, propeller pitch, rpm, mixture setting, % of horsepower used
        2. Compare the expected burn based on performance charts to the actual burn
            a. Adjust as necessary – make a fuel stop, if required

d. Of course, all of this should be entered in the Nav Log

F. Use of an EFB, if used AI.II.I.K14
    i. Apps such as ForeFlight can be great tools for flight planning, and cross-country flying
    ii. Enter the flight plan – the app can take care of the majority of, if not all, calculations based on your inputs
    iii. Ensure understanding and proficiency with the app used

5. VFR Flight Plan AI.II.I.K6, AI.II.I.K8

A. Not required but it is a good operating practice since the info can be used for search and rescue
B. Filing can be done on the ground or in the air
    i. On the ground: Call the FSS (1 800-WX BRIEF), various apps such as ForeFlight have this ability as well (assuming you have a Wi-Fi or data connection)
    ii. After takeoff, contact the FSS by radio and give them the takeoff time to activate the flight plan
    iii. Once filed, the flight plan will be held for an hour after the proposed departure time
        a. The departure time can be revised, if necessary
C. Don't forget to close the flight plan
    i. This should be done via telephone to avoid radio congestion
    ii. The FAA will assume you are lost/didn't make it to the destination and institute a search 30 min after the scheduled arrival time if the flight plan is not closed
D. ICAO Flight Plans
    i. Here we'll go over the more complicated and detailed portion of the ICAO flight plan
        a. For details on every aspect of the flight plan, see:
            - AIM 5-1-5 Flight Plan – VFR Flights
            - Appendix 4. FAA Form 7233-4 – International Flight Plan
    ii. Flight Rules
        a. Flight rules are always required.
        b. Flight rules should indicate:
            - I for IFR
            - V for VFR
            - For a composite flight, (IFR then VFR or VFR then IFR), submit separate flight plans for the IFR and VFR portions of the flight. Filing a single flight plan for a composite flight (flight rules "Y" or "Z") is not supported currently. The IFR plan will be routed to ATC, and the VFR flight plan will be routed to a Flight Service for Search and Rescue services.
    iii. Type of Flight
        a. Entering the type of flight is entirely optional for flights wholly within US Domestic Airspace
        b. In the case that you do need to include the type of flight, indicate it as follows:

- G - General Aviation
- S - Scheduled Air Service, N - Non-Scheduled Air Transport Operation, M – Military, D - DVFR
- X - other than any of the defined categories above

iv. Wake Turbulence Category
   a. H - HEAVY, indicates an aircraft type with a max certificated take-off mass of 300,000 lbs. or more
   b. M - MEDIUM, to indicate an aircraft type with a maximum certificated take-off mass of less than 300,000 lbs. but more than 15,500 lbs.
   c. L - LIGHT, indicates an aircraft type with a maximum certificated take-off mass of 15,500 lbs. or less

v. Aircraft Equipment
   a. The ICAO system lets the pilot pick and choose the equipment and capabilities specific to their aircraft
   b. Equipment and capabilities that require indication include:
      - Navigation
      - Transponder
      - ADS-B
      - Additional information may be required in the Remarks section for:
         a PBN, RVSM, Data Communications, more on this below
   c. There are two parts to the Equipment box. The first part is the Aircraft Equipment followed by a slash and the second portion, the Transponder Capability.
      - Aircraft Equipment
         a Standard Capability (S)
            1. To simplify filing, the code "S" can be included to indicate Standard Capability
               a. Includes VHF radio, VOR, and ILS
         b No Capability (N)
            1. When there is no navigation, communications, or approach capability file the letter N
         c More Capabilities in Appendix 4 Table 4-2
      - Transponder Capability in Appendix 4 Table 4-3
   d. Example
      - If your aircraft had:
         a A VHF Radio, VOR and ILS	S
         b An IFR approved GPS	G
         c PBN Capable	R
            1. If you can accept PBN routes and procedures. PBN is a new concept encompassing both RNAV and RNP. If you're using RNAV or RNP for any phase of the flight, this applies to you.
         d Mode C Transponder	C
      - The final entry in Box 10 would be SGR/C
      - We mentioned earlier that Remarks may be required for PBN aircraft. By listing PBN (R) in your equipment, you only notified ATC that your equipment is PBN approved. Since PBN describes many different types of equipment, you must specify what you're equipped with in the Remarks, box 18.
         a Most general aviation piston aircraft will enter: PBN/B2C2D2
            1. B2= RNAV 5 capability, C2 = RNAV 2 capability, D2 = RNAV 1 capability
            2. By listing this code, you are telling ATC you are capable of handling RNAV based procedures for the enroute structure and terminal procedures.

vi. For more information:
   a. A great, short ICAO flight plan instructional video from AOPA
   b. ICAO Flight Plan instructions
   c. FAA Aircraft Type Designators
   d. ICAO Flight Plan Form

- e. AIM 5-1-9 – International Flight Plan - IFR Flights
- E. Use of an EFB, if used AI.II.I.K14
  - i. Apps such as ForeFlight can file (and even activate) your flight plan
  - ii. Ensure understanding & proficiency

6. Weather Check & Decision-Making AI.II.I.K7

- A. Obtaining a preflight weather briefing is the first step to determine if the flight can be conducted safely
  - i. Often done in conjunction with filing the flight plan
    - a. See III.C. Weather Information for more detailed weather information
  - ii. It also shows where problems may occur during the flight
- B. FAR 91.103 requires familiarity with weather reports and forecasts for the flight
- C. RM: Go/No Go
  - i. Good judgment is necessary in deciding whether to take the flight
    - a. A gutsy, dangerous condition could end badly
  - ii. Go/No Go decision making continues throughout the flight
  - iii. RM: Use the PAVE risk management checklist
    - a. Pilot AI.II.I.R1
      - IMSAFE, proficiency, currency, etc.
      - Set limits and don't bend them
        - a Ex: numerous conditions may be an automatic no go
          - 1. Thunderstorms, icing, moderate or greater turbulence, fog, etc.
        - b Personal limitations will vary based on the pilot and the aircraft
          - 1. These must always meet or exceed any FARs or aircraft limitations
          - 2. Ex: have personal crosswind limitations, visibility requirements, rest requirements, etc.
      - Physical/Mental condition
        - a Sick, tired, upset, depressed – These factors can greatly affect the ability to handle any problem
        - b IMSAFE checklist
      - Recent Flight Experience
        - a Don't go beyond your abilities or the aircraft's abilities
        - b Ex: Are you comfortable in MVFR if you haven't flown in a while
    - b. Aircraft AI.II.I.R2
      - Performance requirements (fuel, altitude, load, etc.), airworthiness, systems & equipment, etc.
    - c. Environment AI.II.I.R3
      - Airport environment, airspace, terrain, obstacles, weather, etc.
    - d. External pressures AI.II.I.R4
      - Reason for the flight, passengers, other pressures
  - iv. Flying is a continual process of decision making before and throughout the entire flight
    - a. Cancel, discontinue the flight/divert, if necessary
- D. Use of an EFB, if used AI.II.I.K14
  - i. Apps such as ForeFlight can provide a legal weather briefing for the flight
  - ii. Ensure understanding & proficiency

7. Planned Calculations versus Actual Results AI.II.I.K11

- A. Planned calculations are never perfect
  - i. Numerous factors can change performance
    - a. Winds may be slightly off or change, TAS may be different, altitude may have to be adjusted for various reasons leading to different winds and airspeed, etc.
- B. Compensate for changes
  - i. Recognize deviations in airspeed, expected winds, time to checkpoints, fuel burn, etc.

a. The more familiar with the route, flight planning, & waypoints, the easier to recognize deviations

ii. If the time to waypoints is too fast or slow, power and airspeed may be adjusted

a. If power/increased fuel burn is a concern, accept the speed and adjust the time to each waypoint

- Use the new GS to estimate the time at each fix

b. Use tools at your disposal

- GPS and tablets can make calculations extremely quick and easy
- If necessary, calculate by hand (estimate as able to save time and maintain awareness)
  a Fly first
- Deviate if the new performance warrants (insufficient fuel, etc.)

iii. Ignoring the problem only makes it worse

a. Invalid fuel and time calculations

b. Potential for loss of situational awareness, and/or getting lost

iv. Recognize the differences, and adjust

C. Use of an EFB, if used

i. Great tool for situational awareness and recognizing planned versus actual results en route

ii. Monitor track and groundspeed relative to what was expected

8. Diversion to an Alternate AI.II.I.K12

A. There will probably come a time when you cannot make it to the planned destination

i. This can result from weather, malfunctions, poor planning, fuel, fatigue/illness, etc.

B. Before flight, check the route for suitable landing areas and for nav aids that can be used in a diversion

C. Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance

i. Use your thumb to estimate distance

a. Using the scale on your map, figure out approximately how far from the fingertip of your thumb (toward the knuckle) 10 nm is

b. In the case of a diversion use your thumb to quickly measure the number of 10 nm increments to the alternate airport

c. This will provide a rough distance estimate for quicker, less stressful time and fuel calculations

ii. Use a compass rose, airway, or any other reference on the chart to determine the approximate new heading

a. Also, a rough estimate to get the airplane heading in the general direction while handling the situation

D. Choose an alternate shown on your sectional or use the 'Nearest' page in the GPS

E. Procedure

i. Find your position on the sectional chart

ii. Divert immediately toward the alternate using shortcuts/rule of thumb calculations (above)

a. Completing all measuring, plotting, computations first may aggravate the situation

iii. Once established on course, note the time

iv. Use the winds aloft nearest the diversion point to calculate a heading and GS

a. Once determined, calculate a new arrival time and fuel consumption

b. Give priority to flying while dividing attention between navigation and planning

v. When determining an altitude, consider cloud heights, winds, terrain, radio reception, etc.

F. Use of an EFB, if used

i. Great tool for diverting – Can provide quick route guidance, and calculations allowing the pilot to keep more focus on flying

ii. Ensure proficiency – Don't allow it to become a distraction

9. Lost Procedures AI.II.I.K12

A. Plan ahead to avoid getting lost

i. The better the planning, the more familiar you'll be with the route

ii. Use multiple sources to monitor location

a. Use pilotage, dead reckoning, as well as radio navigation/GPS to navigate

iii. Flight Following
  a. As much as possible, use flight following
  b. Controller workload/radar limitations prevent flight following from being used 100% of the time

B. If Lost
  i. Don't Panic
  ii. The Five C's
    a. Climb – This will allow you to see more ground, increasing chances of spotting a landmark
      - Improves radio reception, extends the transmitter range, and increases radar coverage
    b. Communicate – use the frequencies on the chart, including RCO frequencies at VOR stations
      - A controller can provide radar vectors
      - Use 121.5 if the situation becomes threatening and squawk 7700
    c. Confess – Tell any ATC facility the situation
    d. Comply – Comply with any ATC suggestions
    e. Conserve – Reduce power/airspeed for max endurance or range (whichever is appropriate)
  iii. In addition,
    a. Check the heading indicator against the magnetic compass
      - If there is an error, note the direction of error before resetting the heading indicator
      - This can help determine whether you are right or left of course
    b. Ex: if the compass indicates 10^{o} > than the heading indicator, you may be to the right of course
  iv. Use navigational radios (VOR/ADF) to attempt to plot your position in relation to two navaids
    a. GPS can also be used to determine location
  v. If near a town the name of the town may be visible on a water tower

C. Use of an EFB, if used
  i. Moving map, if equipped, is a great tool to avoid becoming lost and maintaining SA
  ii. Ensure proficiency without the app, in the case it was to fail

10. Flight Following & Intercept Procedures AI.II.I.K13

A. Flight Following
  i. Radar equipped ATC facilities can provide radar assistance & navigation services to VFR aircraft, provided:
    a. You can communicate with ATC, are within radar coverage, and can be radar identified
    b. Highly beneficial and should be used whenever available
  ii. RM: Limitations of ATC Services AI.II.I.R5
    a. Based on controller discretion
      - Radar limitations, traffic volume, controller workload/frequency congestion may prevent the service
      - Controller's reasoning for not providing the service is not subject to question or necessary to explain
    b. Guidance information is advisory and responsibility for safe flying remains with the pilot
    c. Cannot determine if flight into IMC will results from their instructions
    d. Can only work with the information and aircraft on hand
      - Limited info on aircraft that are not participating and where they're going/what they're doing

B. Intercept Procedures (AIM 5-6-13 Interception Procedures)
  i. In conjunction with the FAA, Air Defense Sectors monitor air traffic and can order an intercept in the interest of national security or defense – reasons include to:
    a. Identify, track, inspect, divert, or establish communications with an aircraft

ii. AOPA Intercept Procedures Card

INTERCEPTING SIGNALS Signals initiated by intercepting aircraft and responses by intercepted aircraft (as set forth in ICAO Annex 2-Appendix 1, 2.1)				
Series	**INTERCEPTING Aircraft Signals**	**Meaning**	**INTERCEPTED Aircraft Responds**	**Meaning**
1	DAY-Rocking wings from a position slightly above and ahead of, and normally to the left of, the intercepted aircraft and, after acknowledgement, a slow level turn, normally to the left, on to the desired heading. NIGHT-Same and, in addition, flashing navigational lights at irregular intervals. *NOTE 1-Meteorological conditions or terrain may require the intercepting aircraft to take up a position slightly above and ahead of, and to the right of, the intercepted aircraft and to make the subsequent turn to the right.* *NOTE 2-If the intercepted aircraft is not able to keep pace with the intercepting aircraft, the latter is expected to fly a series of race-track patterns and to rock its wings each time it passes the intercepted aircraft.*	You have been intercepted. Follow me.	AEROPLANES: DAY-Rocking wings and following. NIGHT-Same and, in addition, flashing navigational lights at irregular intervals. HELICOPTERS: DAY or NIGHT-Rocking aircraft, flashing navigational lights at irregular intervals and following.	Understood, will comply.
2	DAY or NIGHT-An abrupt break-away maneuver from the intercepted aircraft consisting of a climbing turn of 90 degrees or more without crossing the line of flight of the intercepted aircraft.	You may proceed.	AEROPLANES: DAY or NIGHT-Rocking wings. HELICOPTERS: DAY or NIGHT-Rocking aircraft.	Understood, will comply.
3	DAY-Circling aerodrome, lowering landing gear and overflying runway in direction of landing or, if the intercepted aircraft is a helicopter, overflying the helicopter landing area. NIGHT-Same and, in addition, showing steady landing lights.	Land at this aerodrome.	AEROPLANES: DAY-Lowering landing gear, following the intercepting aircraft and, if after overflying the runway landing is considered safe, proceeding to land. NIGHT-Same and, in addition, showing steady landing lights (if carried). HELICOPTERS: DAY or NIGHT-Following the intercepting aircraft and proceeding to land, showing a steady landing light (if carried).	Understood, will comply.

INTERCEPTING SIGNALS Signals and Responses During Aircraft Intercept Signals initiated by intercepted aircraft and responses by intercepting aircraft (as set forth in ICAO Annex 2-Appendix 1, 2.2)				
Series	**INTERCEPTED Aircraft Signals**	**Meaning**	**INTERCEPTING Aircraft Responds**	**Meaning**
4	DAY or NIGHT-Raising landing gear (if fitted) and flashing landing lights while passing over runway in use or helicopter landing area at a height exceeding 300m (1,000 ft) but not exceeding 600m (2,000 ft) (in the case of a helicopter, at a height exceeding 50m (170 ft) but not exceeding 100m (330 ft) above the aerodrome level, and continuing to circle runway in use or helicopter landing area. If unable to flash landing lights, flash any other lights available.	Aerodrome you have designated is inadequate.	DAY or NIGHT-If it is desired that the intercepted aircraft follow the intercepting aircraft to an alternate aerodrome, the intercepting aircraft raises its landing gear (if fitted) and uses the Series 1 signals prescribed for intercepting aircraft. If it is decided to release the intercepted aircraft, the intercepting aircraft uses the Series 2 signals prescribed for intercepting aircraft.	Understood, follow me. Understood, you may proceed.
5	DAY or NIGHT-Regular switching on and off of all available lights but in such a manner as to be distinct from flashing lights.	Cannot comply.	DAY or NIGHT-Use Series 2 signals prescribed for intercepting aircraft.	Understood.
6	DAY or NIGHT-Irregular flashing of all available lights.	In distress.	DAY or NIGHT-Use Series 2 signals prescribed for intercepting aircraft.	Understood.

Conclusion:
Brief review of the main points
Cross country flight planning requires a lot of preflight work but the flight itself is worth the time. It also helps to prevent getting lost and keeps us away from potentially dangerous or bad weather.

II.J. 14 CFR & Publications

References: 14 CFR Parts 1, 61, 91, NTSB Part 830, Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM

Objectives	The learner should develop knowledge of the elements related to federal aviation regulations and publications.
Key Elements	1. Chart Supplement 2. ACs 3. NOTAMs
Elements	1. FARs 2. NTSB Part 830 3. Aviation Publications
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the purpose and content of the FARs as well as useful publications.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Where everything you've been looking for and will ever need to know is kept.

Overview

Review Objectives and Elements/Key ideas

What

The Federal Aviation Regulations (FARs) and publications relevant to every pilot.

Why

To provide a better understanding of these publications, their applicability to you, their use in relation to flying, and where to find specific information.

How:

1. **FARS (1, 61, 91, 21, 39, 43, 67)** AI.II.J.K1
   A. Part 1 – Definitions and Abbreviations
      i. Provides general definitions as well as abbreviations and symbols
      ii. Contents
         a. General Definitions
         b. Abbreviations and Symbols
         c. Rules of Construction
   B. Part 61 – Certification: Pilots, Flight Instructors, and Ground Instructors
      i. Requirements for issuing pilot, flight instructor, and ground instructor certificates, ratings, and authorizations
      ii. Conditions under which those certificates, ratings, and authorizations are necessary
      iii. Privileges and limitations of the certificates, ratings, and authorizations
      iv. Subparts
         a. General
         b. Aircraft Ratings and Pilot Authorization
         c. Student Pilots
         d. Recreational Pilots
         e. Private Pilots
         f. Commercial Pilots
         g. Airline Transport Pilots
         h. Flight Instructors
         i. Ground Instructors
         j. Sport Pilots
         k. Flight Instructors with a Sports Pilot Rating
   C. Part 91 – General Operating and Flight Rules
      i. Prescribes rules governing the operation of aircraft within the United States, including the waters within 3 nautical miles of the US coast
      ii. Subparts
         a. General
         b. Flight Rules (General, VFR, IFR)

c. Equipment, Instrument, and Certificate Requirements
d. Special Flight Operations
e. Maintenance, Preventive Maintenance, and Alterations
f. Large and Turbine Powered Multiengine Airplanes and Fractional Ownership Program Aircraft
g. Additional Equipment and Operating Requirements for Large and Transport Category Aircraft
h. Foreign Aircraft Operations and operations of US Registry Civil Aircraft Outside of the US; and rules Governing Persons on Board Such Aircraft
i. Operating Noise Limits
j. Waivers
k. Fractional Ownership Operations

D. Part 21 – Certification Procedures
   i. Requirements for issuing and changing design approvals, production approvals, airworthiness certificates, and airworthiness approvals
E. Part 39 – Airworthiness Directives
   i. Provides a legal framework for the FAA's system of Airworthiness Directives
F. Part 43 – Maintenance
   i. Rules governing maintenance, preventive maintenance, and rebuilding
G. Part 67 – Medical Standards and Certification
   i. Medical standards and certification for issuing medical certificates

2. NTSB (National Transportation Safety Board) Part 830 AI.II.J.K2

A. Part 830 contains rules pertaining to:
   i. Initial notification and reporting of aircraft incidents and accidents
      a. Immediately (most expeditious means available) notify the nearest NTSB office for:
         - Accident or serious incident (listed in 830.5a)
         - Aircraft is overdue and believed to have been involved in an accident
      b. Information to be provided described in 830.6
   ii. Preservation of aircraft wreckage, mail, cargo, and records involving all civil and certain public aircraft accidents
B. Subparts include:
   i. General: [830.1]Applicability; [830.2]Definitions
   ii. Initial Notification of Aircraft Accidents, Incidents, and Overdue Aircraft: [830.5]Immediate Notification; [830.6]Information to be Given in Notification
   iii. Preservation of Aircraft Wreckage, Mail, Cargo, and Records: [830.10]Preservation of Aircraft Wreckage, Mail, Cargo and Records
   iv. Reporting of Aircraft Accidents, Incidents, Overdue Aircraft: [830.15]Reports and Statements to be Filed

3. Aviation Publications

A. FAA Advisory Circular (AC) AI.II.J.K3
   i. FAA Advisory Circular Search
   ii. An informational document that the FAA wants to distribute to the aviation community
      a. Information only and are not regulations
   iii. May be needed to:
      a. Provide an acceptable, clearly understood method for complying with a regulation
      b. Respond to a request from a government entity (NTSB, Office of the Inspector General, etc.)
      c. Expand on standards needed to promote aviation safety, including the safe operation of airports
   iv. Issued in a number system corresponding with the subjects in the FARS:

00 – General	140 – Schools and Other Certificated Agencies
10 – Procedural Rules	150 – Airport Noise Compatibility Planning
20 – Aircraft	170 – Navigation Facilities

60 – Airmen
70 – Airspace
90 – Air Traffic and General Operating Rules
120 – Air Carriers, Air Travel Clubs, and Operators for Comp/Hire: Certification and Ops
180 – Administrative Regulations
190 – Withholding Security Information
210 – Flight Info (Aeronautical charts, doesn't relate to the FARs)

v. Commonly used ACs: The Backseat Pilot – Advisory Circulars

B. INFOs & SAFOs AI.II.J.K3
  i. InFO (Information for Operators)
    a. Contains valuable information for operators to help meet certain administrative, regulatory, or operational requirements with relatively low urgency or impact on safety
      - Example: Updates to Cold Temperature Airports Program
    b. Links
      - FAA Introducing InFO document
      - InFO Database
  ii. SAFO (Safety Alert for Operators) AI.II.J.K3
    a. Designed to share important safety information broadly and quickly, may include recommended actions
      - Especially valuable to air carriers and their duty to provide service with the highest degree of safety
      - Although primarily useful to air carriers, there are SAFOs useful and applicable to GA flying
      - Example: Recognizing & Mitigating GPS/GNSS Disruptions
    b. Training center managers should pay attention to any SAFO bearing directly on their operation and consider immediate implementation of any applicable actions recommended
    c. Links
      - FAA Introducing SAFO document
      - SAFO Database

C. Airman Certification Standards (ACS) / Practical Test Standards (PTS) AI.II.J.K4
  i. PTS/ACS Concept
    a. PTS: FAR Part 61 specifies the Areas of Operation in which knowledge and skill must be demonstrated by the applicant before issuance of a certificate
      - The FARs provide the flexibility that permits the FAA to publish practical test standards containing Areas of Operation and specific Tasks in which competency must be demonstrated
    b. The ACS integrates the elements of knowledge, risk management, and skill listed in FAR Part 61 for each airman certificate or rating
  ii. Current PTS for Airplanes
    a. Sport, Flight Instructor Instrument, and Type Rating
  iii. Airman Certification Standards (ACS)
    a. Essentially an "enhanced" version of the PTS
    b. Updated and modernized certification standards
    c. So far, the FAA has released the Private Pilot, Instrument Rating, Commercial, ATP, and Instructor ACS
      - The rest will be transitioned/released at a later date

D. Pilot's Operating Handbook (POH) AI.II.J.K5
  i. The POH describes the specific airplane and its operation
  ii. Standard sections include:
    a. General
    b. Limitations
    c. Emergency Procedures
    d. Normal Procedures
    e. Performance
    f. Weight and Balance

    g. Airplane and Systems Description
    h. Handling, Preventative and Corrective Maintenance
    i. Supplements

E. Aeronautical Information Manual (AIM) AI.II.J.K6
  i. The official guide to basic flight information and ATC procedures for the aviation community flying in the NAS of the United States
    a. Basically, the "pilot's bible"
  ii. Contains information such as health and medical facts, flight safety, a pilot/controller glossary, information on safety, accidents, and reporting of hazards
    a. Chapter 1: Navigation
      - Nav aids, PBN/RNAV
    b. Chapter 2: Lighting and Airport Visual Aids
      - Lighting aids, obstruction lighting, airport markings and signs
    c. Chapter 3: Airspace
      - Controlled, Class G, Special use, other
    d. Chapter 4: Air Traffic Control
      - Services, communication phraseology and techniques, airport operations
    e. Chapter 5: Air Traffic Procedures
      - Preflight, departure, en route, arrival procedures, pilot and controller responsibilities
    f. Chapter 6: Emergency Procedures
      - Emergency services, distress/urgency procedures, radio comm failure, rescue comms
    g. Chapter 7: Safety of Flight
      - Cold weather altimeter errors, wake turbulence, flight hazards
    h. Chapter 8: Medical Facts for Pilots
      - Medical certification, illness, medication, alcohol, aeromedical factors, fitness for flight
    i. Chapter 9: Charts and Related Publications
      - Types and descriptions of charts

F. RM: Expired Publications AI.II.J.R1
  i. FAR 91.103 requires each PIC to become familiar with all available information concerning that flight
    a. Although it doesn't specifically require it, you should always carry current publications
  ii. Information changes rapidly, out of date publications may be missing crucial information
    a. Frequency changes, newly constructed obstructions, etc.
  iii. It is not FAA policy to initiate enforcement action against a pilot for having expired publications
    a. However, if involved in an enforcement investigation and there is evidence that out-of-date publications contributed to the situation, that information could be used in any enforcement action
  iv. To confirm currency, refer to the next scheduled edition date printed on the cover
    a. Use the FAAs Dates of Latest Editions to verify you have the most current edition
    b. Prior to expiration, check NOTAMs and Safety Alerts and Charting Notices for any changes
  v. Bottom line, use current publications

Conclusion:
Brief review of the main points
The FARs and publications provide many resources to help in flying, obtaining licenses, as well as building aeronautical knowledge.

II.K. Endorsements & Logbook Entries

References: 14 CFR part 61, Certification: Pilots and Flight and Ground Instructors (AC 61-65), Currency Requirements and Guidance for the Flight Review and Instrument Proficiency Check (AC 61-98), Flight Instructor Refresher Course (AC 61-83), WINGS Pilot Proficiency Program (AC 61-91), FAA Order 8900.1 (FSIMS)

Objectives	The learner should develop knowledge of the elements related to logbook entries and endorsements as required by the appropriate ACS.
Key Elements	1. AC 61-65 2. Endorsements 3. Required Records
Elements	1. Logbook Entries 2. Student Pilot Certificate Endorsements 3. Preparation of a Practical Test Recommendation 4. Additional Ratings 5. Reapplying for a Practical Test 6. Time Limits 7. Flight Review Endorsements 8. Flight Instructor Responsibilities 9. Maintaining your CFI Certificate
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands what is necessary in learner's logbooks, what is necessary for student pilot certificates and preparing a learner for a practical test, as well as the requirements for flight review endorsements and flight instructor records.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Don't get stuck with your student at a check ride without the proper endorsements! And don't get stuck not retaining the necessary records in the case that the FAA comes knocking!

Overview

Review Objectives and Elements/Key ideas

What

The necessary entries instructors must make in their learner's logbooks as well as the endorsements required for different practical tests, reviews, etc.

Why

It is important that the instructor understands the requirements to keep the learner's logbook and training in order, not only for the learner's well-being, but also to comply with the FARs.

How:

1. **Logbook Entries** (FAR 61.189) AI.II.K.K1
   A. A flight instructor must sign the logbook of each person that instructor has given flight/ground training
   B. Logbook entries must include (FAR 61.51):
      - Date
      - Airplane Make and Model
      - Total Flight Time
      - Location of Departure and Arrival
      - Aircraft Identification
      - Type of Experience (Solo, PIC, etc.)
      - Flight Conditions (Day, Night, Instrument, etc.)
      - Name of safety pilot, if required
2. **Student Pilot Certificate Endorsements** (Including appropriate logbook entries) AI.II.K.K2, AI.II.K.K3
   A. Student Pilot Endorsements (Examples shown in AC 61-65)

Solo Flight Endorsements	**XC Endorsements**
• Pre-solo Aeronautical Knowledge: 61.87(b)	• Solo XC Training: 61.93(c)(1) and (2)
• Pre-solo Flight Training: 61.87(c)	• Solo XC Planning: 61.93(c)(3)
• Pre-solo Flight Training at Night: 61.87(c) & (o)	• Repeated Solo XCs not > 50 nm from the departure: 61.93(b)(2)
• Solo Flt (1st 90-days): 61.87(n) / Additional 90 days: 61.87(p)	**Class B Endorsements**
• Solo T/O & LDGs at an Airport within 25 nm: 61.93(b)(1)	• Solo Flight in Class B Airspace: 61.95(a)
• TSA US Citizenship: 49 CFR 1552.3(h)	• Solo Flight, to/from/at a Class B airport: 61.95(b) & 91.131(b)(1)

   B. Pre-Solo
      i. AC 61-65 A.3: Pre-solo Aeronautical Knowledge: 61.87(b)
      ii. AC 61-65 A.4 Pre-solo Flight Training: 61.87(c)(1) & (2)
      iii. AC 61.65 A.5 Pre-solo Flight Training at Night 61.87(o)
   C. Solo Flight
      i. Endorsement for the specific make & model aircraft by the instructor who gave the training within the preceding 90 days
         a. AC 61-65 A.6: Solo Flight (first 90 calendar-day period): 61.87(n)
         b. AC 61-65 A.7: Solo Flight (each additional 90 calendar0day period): 61.87(p)
   D. Cross Country
      i. AC 61-65 A.8: Solo Takeoffs and Landings at another Airport withing 25 NM: 61.93(b)(1)
      ii. FAR 61.93(c): Solo Cross Country

a. Must have a solo cross-country endorsement from the authorized instructor who conducted the training that is placed in the person's logbook for the specific category of aircraft to be flown
b. Must have a solo cross-country endorsement from an authorized instructor that is placed in that person's logbook for the specific make and model of aircraft to be flown
c. For each cross-country flight, the authorized instructor who reviews the cross-country planning must make an endorsement in the person's logbook after reviewing that person's planning
d. AC 61-65 A.9: Solo Cross Country Flight: 61.93(c)(1) & (2)
e. AC 61-65 A.10: Solo Cross-Country Flight: 61.93(c)(3)
   - Required for each cross-country flight

E. TSA US Citizenship
   i. Instructor must keep a copy of the documents used to provide proof of citizenship for 5 years, or
   ii. Make the following endorsement:
      a. AC 61-65 A.14: Endorsement of US Citizenship recommended by the TSA: 49 CFR 1552.3(h)

F. Special Federal Aviation Regulation (SFAR)
   i. Mentioned in the ACS – Included here in case it comes up (discuss at your own risk)
   ii. Temporary regulations issued by the FAA that apply to specific people and aircraft
      a. Often issued with an expiration date that can be amended, extended or rescinded as needed
      b. Ex: In 2020, the FAA issued an SFAR to provide regulatory relief to people/schools who were unable to comply with training, experience, testing, and checking requirements due to Covid
         - Extended expiration dates for medical certificates, instructor certificates, practical tests, etc.
   iii. Part 61 SFARs
      a. SFAR 73: Robinson R-22/R-44 Special Training & Experience Requirements
         - Not applicable to airplanes, but you can see sample endorsement requirements (also in AC 61-65)
      b. SFAR 100-2: Relief for US Military/Civilians assigned outside the US in Support of Armed Forces Ops
   iv. The only SFARs listed in the part 91 SFARs prohibit flight in other parts of the world
      a. Ex: Damascus, Somalia, Pyongyang, Tehran, and more

3. Preparation of a Practical Test Recommendation AI.II.K.K4

A. Endorsements AI.II.K.K4a
   i. AC 61-65 A.1: Prerequisites for a Practical Test: 61.39(a)(6)(i) & (ii)
      a. Except as provided by 61.39, each applicant must have received an endorsement from an authorized instructor who certified that the applicant received and logged the required flight time/training in preparation for the practical test within 2 calendar months preceding the month of application of the test and is prepared for the practical test
   ii. AC 61-65 A.2: Aeronautical Knowledge Test Deficiencies: 61.39(a)(6)(iii)
      a. As required
      b. Endorsement stating the applicant has satisfactory knowledge of the subject areas they were deficient in as shown by the Knowledge Test Report
      c. Sometimes included in the above endorsement (Ex. AC 61-65 A.40: Instrument rating)
   iii. Part 61 required endorsements for the category, class, rating, or privilege of certification sought
      a. Vary by rating, shown below

B. Example Endorsement – Single Engine Private Pilot
   i. AC 61-65 A.1: Prerequisite for a Practical Test: § 61.39(a)(6)(i) & (ii)
   ii. AC 61.-65 A.2: Aeronautical Knowledge Test Deficiencies: § 61.39(a)(6)(iii)
   iii. AC 61-65 A.32: Aeronautical Knowledge Test: §§ 61.35(a)(1), 61.103(d), and 61.105
      a. Part 61 required endorsement specific to the private pilot required knowledge training
   iv. AC 61-65 A.33: Flight Proficiency/Practical Test: §§ 61.103(f), 61.107(b), and 61.109
      a. Part 61 required endorsement specific to the private pilot certificate

C. Endorsement References

Sport Pilot	**Flight Instructors (w/o Sport Rating)**
Knowledge Test - 61.307(a)	FOI Knowledge Test - 61.183(d), 61.185(a)(1)
Practical Test - 61.307(b)	Practical Test - 61.183(g), 61.187(a) & (b)
Recreational Pilot	Spin Training - 61.183(i)(1)
Knowledge Test - 61.35(a)(1), 61.96(b)(3), 61.97(b)	CFII Practical Test - 61.183(g), 61.187(a) & (b)(7)
Practical Test - 61.96(b)(5), 61.98(a) & (b), 61.99	**Flight Instructors (with Sport Rating)**
Private Pilot	FOI Knowledge Test - 61.405(a)(1)
Knowledge Test - 61.35(a)(1), 61.103(d), 61.105	Sport Pilot Knowledge Test - 61.35(a)(1), 61.405(a)
Practical Test - 61.103(f), 61.107(b), 61.109	Practical Test - 61.409, 61.411
Instrument Rating (CFII is Required)	Spin Training - 61.405(b)(1)(ii)
Knowledge Test - 61.35(a)(1), 61.65(a) & (b)	**Additional Qualifications**
Practical Test - 61.65(a)(6)	Additional Category/Class Rating (Not ATP) - 61.63(b) or (c)
Commercial Pilot	Additional Type Rating Only (Not ATP) - 61.63(d)(2) & (3)
Knowledge Test - 61.35(a)(1), 61.123(c), 61.125	Type Rating & Category/Class Rating - 61.63(d)(2) & (3)
Practical Test - 61.123(e), 61.127, 61.129	Additional Aircraft Rating (ATP) - 61.157(b)(1)
-You may complete the endorsement in the space at the bottom of the computer test report in the case of a knowledge test failure. You must sign the block provided for the instructor's endorsement on the reverse side of the 8710 for each retake of a practical test. An applicant may retake a practical or knowledge test after receiving additional instruction and an instructor's endorsement.	Type Rating Only (ATP) - 61.157(b)(2)
	Practical Test Prerequisites Completion - 61.39(a)(6)
	Retesting for Knowledge/Practical - 61.49
	Home Study Curriculum - 61.35(a)(1)
	Ground Instructor Experience Reqs - 61.217(b)

D. The instructor and student must complete the IACRA rating application online (iacra.faa.gov)
   i. Or the instructor/student must complete and sign a Form 8710-1
      a. This is given to the examiner at the practical test
      b. Most examiners no longer use this method, IACRA is heavily preferred
E. Except in certain instances, applicant must hold at least a current 3rd class medical: FAR 61.123(a)(3)(iii)

4. **Additional Ratings** (FAR 61.63) AI.II.K.K4b, AI.II.K.K4c
   A. Category and Class Ratings
      i. Additional category and/or class (other than ATP), must have:
         a. Instructor recommendations
         b. Appropriate endorsements
            - Vary by specific FAR 61 requirements
      ii. Applicant must:
         a. Comply with the requirements of FAR 61.63 (described below)
         b. Pass the practical test appropriate for the aircraft category, and if applicable, class rating sought
   B. Additional Class Requirements – FAR 61.63(c)
      i. Endorsement stating competence in knowledge areas and proficient in areas of operation
         a. AC 61-65 A.74: Additional Aircraft Category or Class Rating (other than ATP)
         b. AC 61-65 A.1: Practical test endorsement
         c. Other endorsement(s) as required, see example
      ii. Pass practical test
      iii. No need to meet the time requirements that apply to the class rating (see FAR for exception)
      iv. No knowledge test, provided applicant holds a rating at the certificate level
   C. Additional Category Requirements – FAR 61.63(b)
      i. Complete training and have the applicable aeronautical experience required by FAR part 61
      ii. Endorsement stating competence in knowledge areas and proficient in areas of operation
         a. AC 61-65 A.74: Additional aircraft category or class rating (other than ATP)
         b. AC 61-65 A.1: Practical Test Endorsement

c. Other endorsement(s), as required

iii. Pass practical test

iv. No additional knowledge test, provided applicant holds a rating at the certificate level

D. Solo Flight Requirements (without the appropriate category/class rating) – FAR 61.31(d)(2)

i. Must have received the FAR required training for the aircraft

ii. AC 61-65 A.72 – Solo PIC when the pilot doesn't hold appropriate category/class

E. Additional Rating Example

i. Single engine private pilot wants to add multiengine class rating

ii. AC 61-65 A.1: Prerequisite for a Practical Test: 61.39(a)(6)(i) & (ii)

iii. AC 61-65 A.74: Additional Aircraft Category or Class Rating (other than ATP): 61.63(c)

iv. AC 61-65 A.68: To act as Pilot in Command in a Complex Aircraft: 61.31(e)

5. Reapplying for a Practical Test

A. Following a Notice of Disapproval

i. A practical test, whether satisfactory or not, uses up the endorsement for that test

ii. Must have another endorsement in accordance with FAR 61.43(f) & 61.49(a)(2) stating the necessary training has been given and they are prepared for the test

a. AC 61-65 A.73 – Retesting after failure of a knowledge or practical test: 61.49

iii. Instructor recommendation (8710/IACRA) is required for a retest

iv. Applicant may receive credit for the Areas of Operation they passed if the remainder of the test is completed within 60 calendar-days after the date that the test was discontinued

B. Following a Letter of Discontinuance

i. No additional endorsements are required

ii. Applicant gets credit for the areas of operation that were passed if the test is completed within 60 calendar-days after the discontinuation date

a. If more than 60 calendar-days has passed, the entire practical test must be accomplished

6. Time Limits (Two Calendar Months vs 60 Calendar-Days)

A. 60 Calendar-Day Time Limit

i. FAR 61.43(e) – Practical test can be discontinued for 4 reasons:

a. Fail one or more areas of operation

b. Inclement weather

c. Airworthiness

d. Safety of flight concern

ii. FAR 61.43(f) – If a test is discontinued per 61.43(e), the applicant gets credit for the areas that they already passed, but

a. FAR 61.43(f)(1) – the remainder of the test must be completed within 60 calendar days

- After 60 calendar days, all areas of operation must be tested

B. 2 Calendar Month Time Limit

i. FAR 61.39(f) – If all increments of a practical test are not completed on the same date, all remaining increments must be completed within 2 calendar months

a. Increment may be because the test was discontinued for reasons stated in 61.43(e), or because it was planned to be conducted in increments

b. FAR 61.43(g): After 2 calendar months, the entire test must be accomplished

ii. Separate time limit from the 60 calendar-day limit

7. Flight Review Endorsements AI.II.K.K5

A. After a satisfactory completion of a flight review, the instructor must endorse the pilot's logbook

i. AC 61-65 A.65: Completion of a Flight Review: 61.56(a) & (c)

B. Instrument Proficiency Checks (IPC)

i. CFII is required to perform an IPC for instrument rated pilots

   ii. AC 61-65 A.67: Completion of an Instrument Proficiency Check: 61.57(d)
  C. No logbook entry reflecting unsatisfactory performance on either flight review is necessary
   i. But a logbook entry for the instruction given should be made

8. Flight Instructor Responsibilities

  A. Records (FAR 61.189) AI.II.K.K6
   i. Must maintain a record in a logbook or a separate document that contains the following:
    a. Name of each person endorsed for solo flight privileges, and the date of the endorsement
    b. Name of each person endorsed for a knowledge or practical test, with the kind of test, date, results
   ii. Must retain the records required for at least 3 years
  B. RM: Limitations & Expiration Dates AI.II.K.R1
   i. Failure to ensure proper endorsements is a serious deficiency in performance
    a. Depending on the situation, the FAA could hold the instructor accountable
   ii. Required limitations & expiration dates are implemented for safety
    a. Ensure proper endorsements and learner understanding of those endorsements

9. Maintaining your CFI Certificate AI.II.K.K7

  A. Duration
   i. FAR 61.19(d): A flight instructor certificate expires 24 calendar months from the month in which it was issued, renewed, or reinstated, as appropriate (Except as specified in FAR 61.197(b))
   ii. Although it expires, you never lose the certificate. It can be renewed (more below)
  B. Renewal (FAR 61.197)
   i. If the certificate has not expired:
    a. Pass a practical test for:
     - One of the ratings listed on your flight instructor certificate
     - An additional flight instructor rating
    b. Submit a signed application with the FAA for one of the following requirements:
     - Endorsed 5 or more students for a checkride in the past 24 calendar months with an 80% or better pass rate on their first attempt
      a Gold Seal Instructor Certificate (apply for renewal/gold seal together if desired)
       1. Requires 10 or more checkride endorsements and an 80% or better first attempt pass rate in the past 24 months
       2. Additional options/information are in FAA Order 8900.1, Vol 5, Chap 2, Section 13
        a. Section 13, Paragraph 5-571(E) shows requirements
     - Served as a company check pilot or check airman, chief flight instructor, Part 121 or 135 instructor, or in a position involving the regular eval of pilots in the past 24 calendar months
     - Completion of an approved instructor refresher course in the past 3 calendar months
      a AC 61-83: Flight Instructor Refresher Course
     - Passed a military instructor pilot or pilot examiner proficiency check in an aircraft in the past 24 calendar months (considerably more detail to this - reference FAR 61.197(4))
    c. WINGS Program
     - Requires evaluating/endorsing at least 15 WINGS-accredited flight activities (min of 5 pilots)
     - FAAST Team Notice – WINGS CFI Renewal Opportunity
     - AC 61-91: WINGS – Pilot Proficiency Programs. See page 5, paragraph 6(e)
   ii. Reinstatement of an expired certificate:
    a. Submit a signed application with the FAA for one of the following requirements
     - An instructor practical test for one of the ratings on the expired certificate per 61.183(h)
     - A practical test for an additional flight instructor rating
     - Passed a military instructor pilot or pilot examiner proficiency check

- Completed a military instructor pilot/pilot examiner training course and received an additional rating appropriate to the flight instructor rating sought

Conclusion:
Brief review of the main points
It is important to know the necessary endorsement and logbook requirements for many common situations. This way, the instructor has an idea of what is necessary prior to sending a student to take a test.

II.M. Night Operations

References: Airplane Flying Handbook , Pilot's Handbook of Aeronautical Knowledge, AIM

Objectives	The learner should develop knowledge of the elements related to night operations and will understand the unique factors inherent to night flight.
Key Elements	1. Off Center Viewing 2. Instrument Indications 3. Maintain Orientation
Elements	1. Eyes at Night 2. Lighting 3. Disorientation and Night Optical Illusions 4. Pilot & Plane 5. Engine Start & Taxi 6. Takeoff & Climb 7. In-Flight Orientation 8. Traffic Patterns 9. Approach and Landing 10. Go Around 11. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner is comfortable their understanding of the factors involved in night operations and can confidently and safely pilot an aircraft at night.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

A lot of people prefer night flying to day flying. The air tends to be smoother; the radios tend to be quieter, there's less traffic, and it's more relaxing.

Overview

Review Objectives and Elements/Key ideas

What

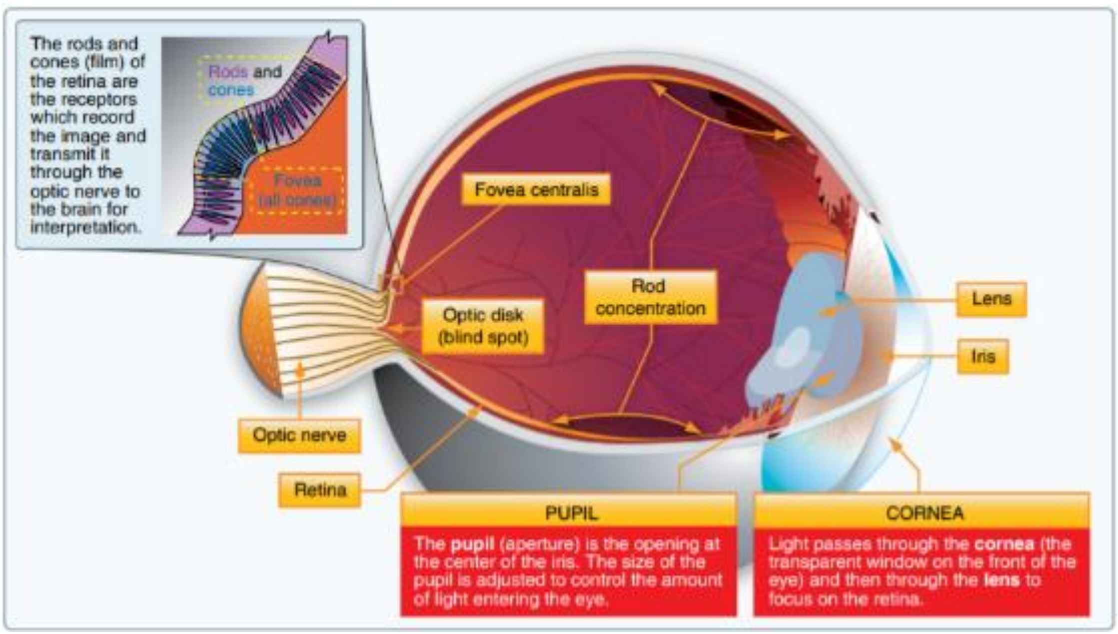
Night operations are the factors dealing with the operation of the airplane at night.

Why

Night flying is very different from day flying - The eyes function differently at night, references available in the day are no longer available at night, there are many illusions that can affect a pilot at night, and more. Flying at night presents unique situations which, if ignored, can lead to dangerous situations.

How:

1. Eyes at Night AI.II.M.K1



A. Rods and Cones
   i. Light enters the eye through the cornea, travels through the lens, and falls on the retina
   ii. The retina contains light sensitive cells that convert light into electrical impulses which are sent to the brain
      a. There are two types of light-sensitive cells, Rods and Cones:
         - Cones - Responsible for color, detail, and far away objects
            a The cones are in the center of the retina
         - Rods – Function when something is seen in the peripherals and provide vision in dim light
            a The rods are in a ring around the cones (peripherals)
   iii. The rods and cones are used differently depending on the ambient light conditions

a. Types of vision: Photopic, Mesopic, Scotopic

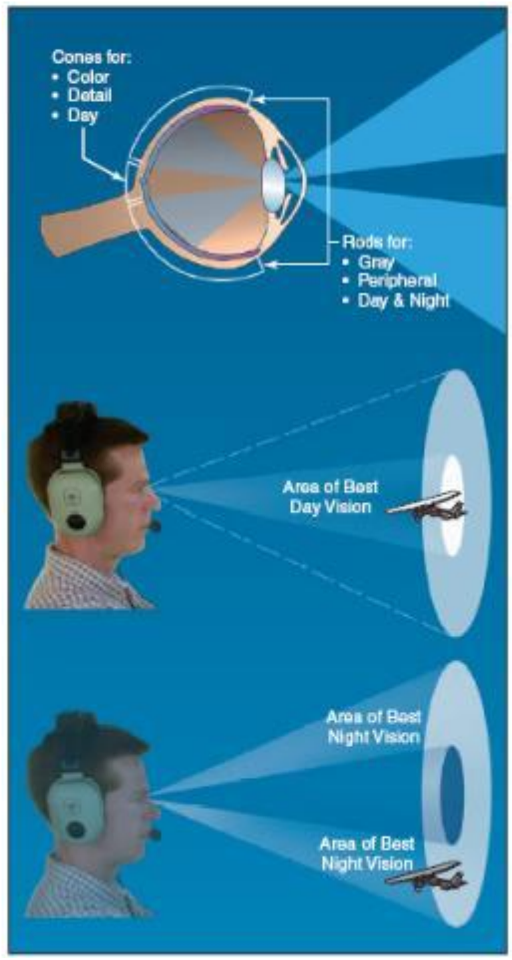
Types of Vision						
Types of vision used	**Light level**	**Technique of viewing**	**Color perception**	**Receptors used**	**Acuity best**	**Blind spot**
Photopic	High	Central	Good	Cones	20/20	Day
Mesopic	Medium/Low	Both	Some	Cones/Rods	Varies	Day/Night
Scotopic	Low	Scanning	None	Rods	20/200	Day/Night

b. Both the cones and rods are used for vision in the day
- But, without normal light, the process of night vision is placed almost entirely on the rods

iv. Rods, Cones, and Night Vision

a. Cones are in the center of the retina (the layer upon which all images are focused)
- There is a small pit called the fovea where almost all the light sensing cells are cones
  - a This is the area where most looking occurs (your center of vision)

b. The Rods



- Make night vision possible
- During daylight, objects can be seen by looking directly at them, using the fovea, but at night off center viewing is more effective
  1. The cones need light to function, without sufficient light (at night, for example) the cones are effectively a blind spot
- Rods are concentrated around the cones and are used to see in dim light
  - a Since cones are only useful with sufficient light and the rods lie outside the fovea (outside the center of vision), off-center viewing is used for night flight
  - b When attempting to find traffic do not stare directly at it, look slightly off to the left or right to allow the rods to see the aircraft
- The problem with rods is that a large amount of light overwhelms them, and they take a long time to reset and adapt to the dark again (Ex: stepping out of a dark movie theatre into the daylight)
  - a The rods can take approximately 30 minutes to fully adapt to the dark
    1. Once fully adapted, the Rods are about 10,000x more sensitive to light
  - b After the rods have adapted to the dark, the process is reversed when exposed to light
    1. Eyes adjust to the light in a matter of seconds
    2. If a dark room is reentered, the 30-min process to adapt is started again
       a. Important to avoid bright lights before and during a flight
       b. Why red flashlights are recommended in flight, they do not disrupt dark adaptation

c. Summary: Night vision is based on the rods and off-center viewing is necessary
- It takes far longer to adapt to the dark than the light – protect your night vision

C. RM: Collision Avoidance AI.II.M.R3

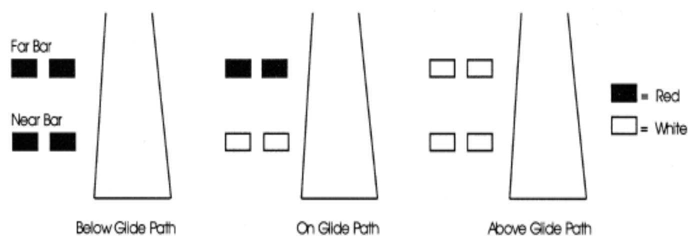
i. Staring directly at an object at night could result in not seeing the object at all since the cones in the center

        of your vision are considerably less effective without sufficient light
    ii. It is important to avoid bright lights before and during a flight to maintain adequate night vision
  D. Flight deck Lighting
    i. Should be at a minimum to allow reading instruments/switches without hindering outside vision

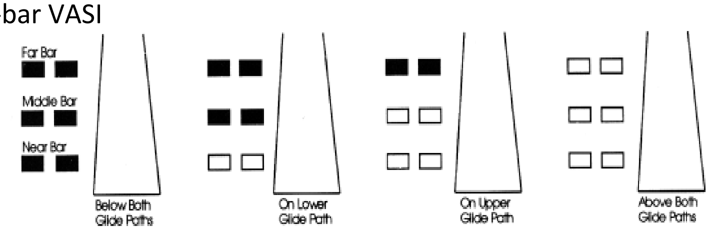
2. Lighting Systems AI.II.M.K2

  A. Taxiway Lighting
    i. Taxiway Edge Lights: Steady blue lights outlining the edges of taxiways
    ii. Taxiway Centerline lights: Steady green lights installed along the centerline of the taxiway
    iii. Clearance Bar Lights: Three in-pavement steady-burning yellow lights
      a. Installed at holding positions on taxiways to increase visibility of the holding position
    iv. Runway Guard Lights
      a. Pair of elevated flashing yellow lights on either side of the taxiway, or a row of in-pavement yellow lights across the entire taxiway at the runway holding position marking
      b. Installed at taxiway/runway intersections
      c. Enhance conspicuity of taxiway/runway intersections
    v. Stop Bar Lights
      a. A row of red, unidirectional, steady-burning in-pavement lights across the entire taxiway at the runway holding position, and elevated steady-burning red lights on each side
      b. A controlled stop bar operates in conjunction with the taxiway centerline lead-on lights
        - Following ATC clearance, the stop bar is turned off and the lead-on lights are turned on
      c. Used to confirm the ATC clearance to enter or cross the active runway in low visibility
  B. Runway Lighting
    i. Runway Edge Lights: White lights except on instrument runways they're yellow for the last 2,000' or half of the runway, whichever is less
      a. Lights marking the end of the runway emit red toward the runway (takeoff) and green outward (landing)
      b. Classified based on brightness: High Intensity Runway Lights (HIRL), Medium (MIRL), and Low (LIRL)
    ii. Runway End Identifier Lights (REIL)
      a. Installed to provide rapid/positive identification of the approach end of a runway
      b. A pair of synchronized flashing lights located on each side of the runway threshold
      c. Effective for:
        - Identification of a runway surrounded by other lighting, or in reduced visibility
        - Identification of a runway which lacks contrast with the surrounding terrain
    iii. Runway Centerline Lighting System (RCLS): If installed, white in-pavement lights every 50' until the last 3,000' of the runway at which point they alternate red and white for 2,000' and are red for the last 1,000'
    iv. Touchdown Zone Lights (TDZL): If installed, two rows of light bars set symmetrically about the centerline
      a. Steady burning white lights starting 100' beyond the landing threshold and extend to 3,000' beyond the threshold or the midpoint of the runway, whichever is less
    v. Taxiway Centerline Lead-Off Lights: Alternate green & yellow lights from the runway centerline to one light position beyond the holding position or ILS critical area holding position
    vi. Taxiway Centerline Lead-On Lights: Same as lead-off lights but leading onto the runway
    vii. Land and Hold Short Lights: Row of pulsing white lights across the runway at the hold short point
      a. Off when LAHSO is not in effect
  C. Approach Lighting
    i. Approach Light Systems (ALS)
      a. Basic means to transition from instrument conditions to visual conditions for landing
        - VFR: Used to identify/recognize the runway
      b. Configuration of lights starting at the threshold and extending into the approach area
    ii. Visual Glideslope Indicators

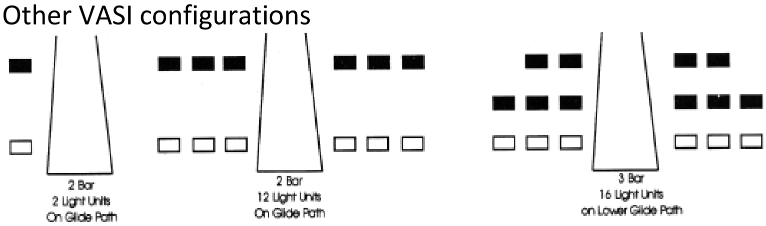
a. Visual Approach Slope Indicator (VASI)
- Provide visual descent guidance during approach
- The lights are visible from 3-5 miles during day and up to 20 or more at night
  - a Safe obstruction clearance within ± 10° of the centerline and 4 NM from the threshold
- Configurations
  - a 2, 4, 6, 12, or 16 light units arranged in bars
    1. Arranged as near, middle, and far bars (Mid provide another glide path for high flight decks)
    2. VASIs of 2, 4, or 6 light units are located on one side of the runway (usually the left)
    3. VASIs consisting of 12 or 16 light units are located on both sides of the runway
  - b Most installations consist of 2 bars and may consist of 2, 4, or 12 light units
- Two Bar VASIs
  - a Provide one visual glide path, normally set at 3°
- Three Bar VASIs
  - a Provide two visual glide paths
    1. The lower glide path is provided by the near and middle bars and is normally set to 3°
       a. Some locations may have up to 4.5° glide paths for proper obstacle clearance
    2. The upper glide path is provided by the middle and far bars and is normally set ¼° higher
- How it Works
  - a Each unit projects light with an upper white segment and a lower red segment
  - b The light units are arranged so that the pilot will see the combinations of lights below:
    1. 2-bar VASI



    2. 3-bar VASI



    3. Other VASI configurations

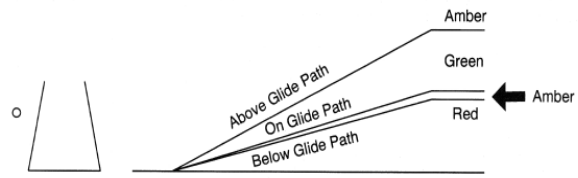


iii. Precision Approach Path Indicator (PAPI)

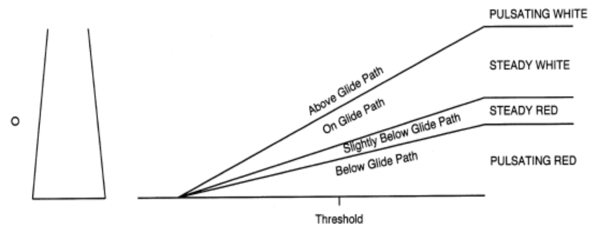
a. General
- Lights arranged to provide visual descent guidance information during the approach to a runway
- Uses light units similar to the VASI but in a single row of either 2 or 4 light units

b. Configuration
- Tri-Color Systems

  - a Normally a single unit projecting a 3-color visual approach path into the final approach area
  - b Glide Path Indications
    1. Below - Red
    2. Above - Amber
    3. On - Green



  - c Useful Range
    1. Day - ½ to 1 mile
    2. Night - Up to 5 miles (depending on visibility)
- Pulsating Systems
  - a Normally a single unit projecting a 2-color visual approach path into the final approach area
  - b Glide Path Indications
    1. Slightly Below - Steady red
    2. Below - Pulsating red
    3. On - Steady white
    4. Slightly Above - Pulsating white
    5. Above - Faster pulsating white
       a. Pulsating increases as aircraft gets further above/below the glide slope



  - c Useful Range
    1. Day, up to 4 miles
    2. Night, up to 10 miles

D. Airport Beacon
  - i. Light Projection
    - a. Omnidirectional & rotate at a constant speed
  - ii. Flashes
    - a. 24-30 per minute for airports/landmarks/points on federal airways; 30-45 per minute for heliports
  - iii. Colors and Combinations of Beacons
    - a. White and Green - Lighted land airport (also green alone*)
    - b. White and Yellow - Lighted water airport (also yellow alone*)
      - *Green/yellow alone is used only in connection with a white-and-green or white-and-yellow beacon
    - c. Green, Yellow, and White - Lighted heliport
    - d. Two quick white flashes followed by a green flash – Military beacon
  - iv. Operation during the day
    - a. Class B, C, D and E: Daylight operation often indicates ground visibility is < 3 miles and/or ceiling < 1,000'
    - b. Don't rely solely on the beacon as there is no regulatory requirements for daylight operation

E. Pilot Control of Airport Lighting (AIM 2-1-8)
  - i. Radio control of lighting is available at some airports by keying the aircraft's microphone
    - a. Often at airports without specified hours for lighting, airports with no tower/FSS, or when closed
  - ii. All radio-controlled lighting systems at an airport operate on the same frequency
    - a. CTAF is used to activate the lights at most airports, but other frequencies may also be used
      - Frequency is in Chart Supplement and standard instrument approach procedures publications
      - Frequency is not on sectional charts
  - iii. Lights operate for 15 minutes

Key Mike	Function
7 times within 5 seconds	Highest intensity available
5 times within 5 seconds	Medium or lower intensity (Lower REIL or REIL-off)

3 times within 5 seconds	Lowest intensity available (Lower REIL or REIL-off)

F. Obstruction Lighting
   i. Aviation Red Obstruction Lights: Flashing red beacons and steady-burning red lights
   ii. Medium Intensity Flashing White Obstruction Lights: Flashing white obstruction lights
      a. Not normally installed on structures less than 200' AGL
   iii. High Intensity White Obstruction Lights: Flashing white lights
   iv. Dual Lighting: Combination of flashing red beacons and steady burning red lights
   v. Catenary Lighting: Light markers for high voltage transmission line catenary wires
   vi. High intensity flashing white lights are being used to identify some supporting structures of overhead transmission lines located across rivers, chasms, gorges, etc. as well as tall structures (chimneys, towers)
      a. Beamed toward the companion structure and identify the area of the wire span

3. RM: **Disorientation and Night Optical Illusions** AI.II.M.K7, AI.II.M.R4, AI.II.M.R5

A. In addition to night vision limitations, night vision illusions can cause confusion
B. Combatting Disorientation / Illusions
   i. Verify Attitude by Reference to Instruments
      a. Best way to cope with disorientation & illusions
   ii. Use vertical guidance as much as possible
      a. If making an approach and an ILS or VASI is available, use it
   iii. Visual references are limited – incorporate the instruments in your scan more often than normal
   iv. If at any time the pilot is unsure of their position, a go around should be executed
C. Autokinesis
   i. Caused by staring at a single point of light against a dark background for over a few seconds
   ii. The light appears to move on its own
   iii. Prevent this by focusing the eyes on objects at varying distances and avoid fixating
      a. Keep the eyes moving and offset/use peripherals
D. Reversible Perspective Illusion
   i. At night, an aircraft may appear to be moving away when it is, in fact, approaching
   ii. Often occurs when flying parallel to another's course
   iii. Observe the aircraft lights and their position on the horizon
      a. If the light intensity increases, the aircraft is approaching
      b. If they dim, it is moving away
E. Size-Distance Illusion
   i. When viewing a source of light that is getting brighter or dimmer, pilots may instead interpret it as approaching or retreating
F. Flicker Vertigo
   i. A light flickering between 4 and 20 cycles per second can produce unpleasant, dangerous reactions
      a. Examples: nausea, vomiting, and vertigo. Convulsions/unconsciousness are possible but rare
   ii. Proper scanning techniques at night can prevent pilots from flicker vertigo

G. False Horizon
   i. Caused when the natural horizon is obscured/not readily apparent
      a. Generated by confusing bright stars and city lights
H. Featureless Terrain
   i. An absence of ground features can create the illusion that the aircraft is higher than it is

- ii. This results in a tendency to fly a lower-than-normal approach
  - a. Elements that can cause visual obscurity can do the same (rain, haze, dark runway environment)
- I. Ground Lighting
  - i. Regularly spaced lights along a road/highway/etc. can appear to be runway lights
  - ii. Lights on moving trains have been mistaken for runway/approach lights
  - iii. Bright runway or approach lights can create the illusion the airplane is closer to the runway
  - iv. Mitigate this as much as possible by maintaining situational awareness
    - a. Know what to expect to see (type of airport/runway lighting), where you expect to see it and know where you are (use navaids, GPS, landmarks, etc.)
- J. Disorientation at Night AI.II.M.K6
  - i. Disregard false sensations and trust the instruments
  - ii. Always verify aircraft attitude with the instruments at night

4. Pilot & Plane AI.II.M.K3, AI.II.M.K4

- A. Night Currency (FAR 61.57(b))
  - i. 3 takeoffs/landings (full stop) in the last 90 days to act as PIC from 1 hour after sunset-1 hour before sunrise
  - ii. RM: Current doesn't imply proficient AI.II.M.R7
    - a. Proficient and safe is based on pilot ability, experience, and training
    - b. Ensure proficiency in addition to currency
- B. Equipment
  - i. Red and/or white light Flashlight
    - a. White light is used to preflight the aircraft
      - Avoid bright white light as much as possible when preparing for night flight
    - b. Red light is used when performing flight deck operations as it will not impair night vision
      - Be cautious, when using a red light on an aeronautical chart, the red colors will wash out
  - ii. Aeronautical Charts
    - a. If the intended course of flight is near the edge of a chart, the adjacent chart should be available
      - City lights can be seen at far distances and confusion can result without the necessary charts
    - b. Colors at night
      - Course lines should be drawn in black to be more distinguishable
      - Using a red/green flashlight will wash out the red/green on the map
  - iii. Regardless of equipment, organization eases the burden on the pilot
- C. Preflight Inspection (FAR 91.205)
  - i. Required equipment for VFR flight at night
    - a. TOMATO FFLAMES (day VFR) and FLAPS (additional night VFR requirements)
      - Fuses (if applicable)
      - Landing Light
      - Anti-Collision Lights
      - Position Lights
      - Source of Power
    - b. Instrument required equipment doesn't hurt (safer is smarter)
  - ii. Walk Around
    - a. The preflight inspection is still necessary
    - b. White light flashlight is good for the inspection (red light for the most part inside the flight deck)
    - c. Check all aircraft lights
    - d. Check the ramp for obstructions
  - iii. RM: Inoperative Equipment AI.II.M.R1
    - a. If inoperative equipment is found, handle it the same as you would during the day, but with the

additional night required equipment
- Is it required by:
  - a Kinds of Equipment List
  - b Type Certificate
  - c Airworthiness Directive
  - d FAR 91.205
  - e And, of course, Personal Minimum requirements
    1. Ex: Instrument required equipment may be a personal minimum for night flight

b. Reference III.B. Airworthiness Requirements for inoperative equipment deferral, etc. details

5. Engine Start, Taxi & Run-up

A. Engine Start
- i. Take extra precaution to be sure the propeller area is clear
  - a. Turn on the rotating beacon and/or flash the position lights
  - b. Carefully scan the area and announce "Clear Prop"
- ii. To avoid battery drain, leave all unnecessary electrical equipment off until after engine start

B. Taxiing AI.II.M.K8
- i. Before Taxi
  - a. Take care of all heads down activities while parked with the brake set
    - Verify GPS operation and database currency - Load all necessary waypoints
    - Setup navaids and frequencies as required
- ii. Taxiing
  - a. Turn on the taxi and/or landing light
    - Continuous use of the landing light at low power settings may put a drain on the electrical system
    - Overheating of the landing light is also possible because of inadequate airflow to keep it cool
    - When using any lights (especially strobes), consideration should be given to not blinding other pilots
  - b. Taxi slowly, particularly in congested areas (collision hazards)
    - Use a speed that allows you to stop if something were to suddenly appear in front of the aircraft
  - c. Look closely for taxiway markings (especially hold short lines)
    - Some airports have lights in the ground along with hold short lines, some don't
    - Use lights/lighted signs along taxiway edges to maintain position
  - d. Perform an instrument check to ensure proper operation prior to takeoff
  - e. Crossing a Runway: Turn on all lights
- iii. RM: Orientation & Situational Awareness AI.II.M.R6
  - a. Airport diagram (always have one out)
  - b. Understand the taxiway markings, lights, and signs
    - The airport can look very different at night
    - Even when familiar, airport lighting/layouts can be disorienting (especially large airports)
  - c. Taxi slowly to allow time to maintain situational awareness
    - Always be aware of where you are and where you're going
  - d. If there is a loss of situational awareness, conflicting information, or doubt, stop and ask for clarification
    - A wrong turn or wrong-surface takeoff can have catastrophic results
  - e. Follow taxiway centerlines and lighting (centerline & edge)
  - f. RM: Be very cautious to avoid an incursion
    - See II.C. Runway Incursion Avoidance for more details

C. Run-up
- i. The before takeoff run-up should be performed with the checklist as usual
  - a. Red light for the checklist

ii. Forward movement of the airplane may not be easy to detect at night
a. Hold/lock the brakes and be alert that the airplane could creep forward without being noticed
iii. Be extra cautious

6. Takeoff & Climb

A. General
i. Night flying demands more attention than day flying
ii. The most noticeable difference is the limited availability of outside visual references
a. Flight instruments should be used to a greater degree at night than in the day AI.II.M.K6
iii. Dim the flight deck lighting so the instruments are readable, without hindering night vision

B. Clear the runway and final approach area for traffic
i. Uncontrolled airport
a. Radios are not required, just because you don't hear anyone doesn't mean they aren't there

C. Entering the runway
i. Turn on all lights, except the landing light
ii. Recommended to align 3' off the centerline to prevent blending in with the runway lights
iii. Check to ensure the magnetic compass and heading indicator match the runway intended
a. Always check you're on the proper runway
b. Accidents have occurred due to crews lining up on the wrong runway at night

D. After receiving takeoff clearance or starting the roll at an uncontrolled field
i. Turn on the landing light
ii. Night takeoff procedures are the same as day takeoffs, except many runway visual cues are not available
a. As airspeed reaches normal lift-off speed, establish a normal climb with outside and inside references
b. Check the flight instruments frequently during takeoff

E. Climb
i. After becoming airborne, the darkness makes it difficult to note if the airplane is climbing or descending
ii. To ensure a climb, check the airspeed indicator, VSI, and altimeter
iii. Necessary pitch/bank adjustments should be made by referencing the attitude/heading indicators
a. Turns should not be made until reaching a safe maneuvering altitude

7. In-Flight Orientation AI.II.M.K5

A. Chart Reading & Navigating at Night
i. Maintaining Night Vision
a. Continue to use red lights in the cockpit to maintain night vision
b. If necessary to turn on white light, cover one eye

ii. Although numerous day references are unavailable, numerous night references can be used instead
a. Anything with bright or a lot of lights - City light patterns, highways, airport beacons, etc.
iii. Chart Reading
a. Ensure the proper charts are organized and accessible
b. Red light distorts chart colors
- Magenta & yellow appear as red & cyan appears as black
- Use it only where optimum outside night vision capability is needed
- Dim white flight deck lighting should be available when needed for map & instrument reading
iv. NAVAIDs/GPS should also be used whenever possible
v. Ground Based Lighting
a. Keep in mind that lighted runways, buildings, etc. may cause illusions when seen from different altitudes
- At 2,000', a group of lights may be seen individually

- At 8,000', the same group could appear as a solid mass

B. Clouds/Restricted Visibility
   i. It is difficult to see clouds at night – be cautious to avoid flying into MVFR/IFR weather conditions
      a. 1st indication - Gradual disappearance of ground/ground lights
      b. Ground fog can be indicated by glowing or a halo around the ground lights
      c. Remember, if a pilot must descend through clouds, haze, etc. the horizontal visibility is considerably less than when looking down through clouds, haze from above
   ii. Be conservative, don't expect to pop out the other side, take action to avoid flying into the clouds

C. Crossing Large Bodies of Water
   i. Very easy to become disoriented
      a. Little to no horizon (black water blends with the black sky)
      b. Stars, lights (from boats, buoys, land, etc.) can blend to produce false horizons and confusion
         - Stars can reflect off the surface of the water creating even more confusion
   ii. The pilot must rely more heavily on the instruments
   iii. Can be potentially hazardous
      a. In the event of an engine failure, the pilot may not have any option other than ditching

D. RM: Position/Navigation Lights (Collision Hazards) AI.II.M.K9, AI.II.M.R3
   i. Red on Left Wing, Green on Right Wing, White on the Tail
      a. Used to orient another aircraft's direction relative to yours

8. Traffic Patterns

A. Identify runway/airport lights as soon as possible
   i. It may be difficult to find the airport or runways (especially if they're buried within a city)
      a. Fly towards the beacon until you identify runway lights
         - White and Green: Lighted civilian land airport
         - White and Green (two quick white flashes, then green): Lighted military airport
         - White and Yellow: Lighted water airport
         - Green, Yellow, and White: Lighted heliport
         - Red flashing beacons indicate obstructions or areas considered hazardous
      b. Compare the runway lights with heading indicator to ensure you are in the right place
      c. If possible, tune the localizer for course guidance to the runway and/or use the OBS function of a GPS to view an extended runway centerline
      d. Use any additional means available to help orient yourself and maintain situational awareness

B. Distance may be deceptive at night due to limited light conditions
   i. A lack of references on the ground and the inability to compare their location and size causes this
   ii. Altitude and airspeed are also difficult to estimate
   iii. More trust must be put on the instruments (particularly the altimeter and airspeed indicator)

C. RM: Ensure appropriate lights are on for collision avoidance AI.II.M.R3
   i. Be attentive to the radios for other aircraft and their location/intentions

D. Fly a normal traffic pattern
   i. Always know the location of the runway/threshold lights
   ii. When entering, allow for plenty of time to complete the before landing checklist
      a. Execute the approach in the same manner as during the day

9. Approach and Landing

A. A stabilized approach should be made in the same manner as during the day

B. Use flight instruments more often (especially altimeter/airspeed indicator)
   i. Distance, height, etc. may be deceptive
   ii. Maintain specified airspeeds on each leg and watch the VSI to keep the approach under control

   iii. A low, shallow approach is not appropriate during a night landing
  C. Final Approach
   i. If there are no centerline lights, align the airplane between the edge lights
    a. Note and correct any wind drift
   ii. Apply power and pitch corrections to maintain a stabilized approach
    a. Use any visual aids to assist in maintaining a proper glideslope (vasi, papi, etc.)
    b. Tune the glideslope if available for additional guidance
  D. Roundout/Touchdown
   i. A smooth, controlled roundout and touchdown should be made in the same manner as in the day
    a. Judgment of height, speed, and sink rate may be impaired due to lack of visual references
     - There is often a tendency to round out too high
   ii. A good rule is to start the roundout when the landing lights reflect on the tire marks on the runway
    a. In the case you have no landing light/can't see tire marks, start the roundout when the runway lights at the far end appear to be rising higher than the nose of the airplane

10. Go Around
  A. A prompt decision is even more necessary at night due to the restricted visibility
   i. Be prepared in case the maneuver is necessary
  B. Fly a normal go around with a greater emphasis on the instrument crosscheck if outside references are lacking

11. RM: **Hazards & Emergencies**
  A. Weather Considerations AI.II.M.R2
   i. Narrow Temperature/Dewpoint Spread
    a. Indicates the possibility of fog
    b. More difficult to see at night - Can unexpectedly fly into fog as well as cloud cover
     - Indications: Strobe flash reflecting in the fog/clouds
   ii. Wind Direction and Speed
    a. The wind's effect on the airplane cannot be as easily detected at night as during the day
  B. Night Emergencies
   i. General
    a. As with any emergency, the pilot should not panic, maintain control of the airplane and attempt to fix the problem/proceed with any emergency procedures
    b. In the case of a night emergency, the pilot will have to expend more energy maintaining airplane control
     - As the checklist is completed, crosscheck the outside visual references (if any), and the instruments to ensure a safe flight attitude is maintained based on the situation at hand
   ii. Electrical Failure
    a. In the case of a suspected problem, follow the checklist in the POH
     - Generally, reduce the electrical load as much as possible
    b. If total failure is expected, land at the nearest airport immediately
     - Transition to backup instruments if applicable
     - Increase the scan as necessary
   iii. Engine Failure
    a. ABCD – Airspeed, Best landing area, Checklist, Distress call
    b. Don't Panic - Establish a normal glide and turn toward an airport or suitable landing area
     - Away from congested areas
     - Consider an emergency landing area near public access (don't land where no one can get to you)
    c. Check to determine the cause and correct it immediately, if possible (Engine restart checklist)
    d. If no restart – Maintain positive control of the airplane at all times!
     - Maintain orientation with the wind – don't land downwind unless there is no other choice

- Check the landing lights and use them on landing if they work

e. Announce the emergency to ATC, UNICOM, and/or guard
- If already on a frequency, talk to them, don't change unless instructed to

f. Before landing checklist
g. Touchdown at the slowest possible airspeed
h. After landing, turn off all switches and evacuate as quickly as possible

C. Distractions, Situational Awareness & Task Prioritization AI.II.M.R4

i. Distractions

a. They're dangerous
- Remove distractions from view – if it's a person, explain the situation and ask them to stop

b. Sterile flight deck
- Sterile flight deck during taxi, takeoff, and climb as well as descent and landing

c. Fly first! Aviate, Navigate, Communicate
- Focus on the tasks at hand and stay ahead of the aircraft
- Ensure checklists have been completed, and both you and the aircraft are prepared for what's next

ii. Situational Awareness

a. Thorough planning
- Route, pilotage, dead reckoning, navaids, waypoints, charts, taxi diagrams, weather, alternates, etc.

b. Ensure backup navigation capabilities
- Pilotage and dead reckoning backed up by VOR and/or GPS, alternate airport options
- Ask for help

c. Request flight following

iii. Task Prioritization

a. On the ground, clearing takes precedence – take care of all heads down activities while stopped
b. Airborne, divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
c. No one responsibility should take your full attention full more than a short period
d. Understand what tasks need to be accomplished and when
- Prioritize them based on importance and time available
- Checklists and standard operating procedures are extremely helpful and enhance safety

e. Recognize when you are getting behind and find a way to catch up
- If more time is needed, find somewhere to hold/circle, or slow down
- Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
- "Attack the closest alligator" – Deal with the most pressing problem

iv. Aviate, Navigate, Communicate

D. Collision Hazards AI.II.M.R3

i. Collision Avoidance

a. Scanning with off-center viewing
b. Clearing Procedures
- Before Takeoff: Scan the runway and final approach for other traffic
- Climbing: Execute gentle banks to allow scanning above/below the wings as well as other blind spots
- Uncontrolled Fields: Be conservative with spacing during takeoff, landing, and in the pattern

c. Clearly communicate intentions & location at uncontrolled fields
- Coordinate with other aircraft

d. Operation Lights On
- Voluntary FAA safety program to enhance the see and avoid concept
- Turn on landing lights during takeoff and when operating below 10,000', day or night
    - a Especially within 10 miles of an airport, in reduced visibility, where flocks of birds are expected

ii. Terrain
  a. Be aware of terrain that could cause a hazard during the climb or descent into the airfield
    - Study terminal charts and IFR & VFR chart altitudes to determine safe altitudes
    - Use maximum elevation figures (MEFs) and other data
    - Chart supplement may list terrain
  b. Day vs Night flying over terrain
    - Be extra vigilant at night, when terrain may be impossible to see until it is too late
    - A personal minimum may be to only fly over high terrain during daylight
  c. Minimum Safe Altitudes (FAR 91.119)
    - Anywhere: At an altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface
    - Over Congested Areas: 1,000' above the highest obstacle within 2,000'
    - Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

iii. Obstacles and Wire Strike
  a. Many structures can significantly affect safety when below 500' AGL and particularly below 200' AGL
    - Become familiar with any obstacles nearby airports
    - Obstacles can be found in the NOTAMs, and the Terminal Procedures (IFR document)
      a Lighting outages can be found in NOTAMs
    - < 200' AGL are unmarked/lighted power lines, antenna towers, etc.
  b. Antenna Towers
    - Numerous antennas extend over 1,000'-2,000' AGL
      a Most are supported by guy wires which are very difficult to see
      b Avoid structures by at least 2,000' as guy wires can extend 1,500' horizontally from a structure
  c. Overhead Wires
    - Overhead transmission wires/lines span runway departures and landmarks pilots frequently follow
      a Lakes, highways, railroad tracks, etc.
    - May not be lighted

iv. Vehicles, Persons, Wildlife, etc.
  a. Be alert for anyone/anything that may cause a hazard
    - Often the ATIS/NOTAMs will inform of potential vehicles/persons working around the airport
    - Wildlife is common around many airports.
  b. Takeoff: Reject the takeoff or delay takeoff, if required
  c. Landing: Go around
  d. Taxiing: Stop until safe (taxi slowly to ensure the ability to stop if something suddenly appears)

Conclusion:
Brief review of the main points
Night operations present unique situations to a pilot and require diligence to maintain orientation and safety. Night flying is not inherently dangerous, but it can require more effort. Overall, though, it is very enjoyable.

II.N. Supplemental Oxygen

References: 14 CFR Part 91, AC 61-107, Airplane Flying Handbook (FAA-H-8083-3), AIM, POH/AFM

Objectives	The learner develops knowledge of the elements related to supplemental oxygen and be able to explain the necessary elements as required in the ACS.
Key Elements	1. Regulations 2. Aviator's Oxygen 3. Decompression and Hypoxia
Elements	1. The High-Altitude Flight Environment 2. Regulatory Requirements 3. Physiological Factors 4. Types of Oxygen Systems 5. Aviator's Breathing Oxygen 6. Care and Storage of High-Pressure Oxygen Bottles
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands and can explain the requirements, elements, and safety procedures involved with supplemental oxygen operations.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

So, you want to fly really high? It's not just that simple. A lot changes as the altitude increases.

Overview

Review Objectives and Elements/Key ideas

What

The required equipment, how it functions, the unique hazards and regulations associated with supplemental oxygen.

Why

There are many advantages to flying at high altitudes (jet engines are more efficient, weather and turbulence can be avoided, etc.). Many modern GA airplanes are being designed to operate in the high-altitude environment, therefore it is important that pilots be familiar with at least the basic operating principles. Oxygen requirements, specifically, vary based on the altitude. Without proper adherence to the regulations and procedures, the pilot is endangering themself and anyone else on the airplane.

How:

1. **The High-Altitude Flight Environment**
   A. FAR 61.31(g) considers all flight operations conducted above 25,000' MSL to be high altitude, however many effects of higher altitudes can be felt well below 25,000'
2. **Regulatory Requirements** (FAR 91.211) AI.II.N.K1
   A. No person may operate a civil aircraft of US registry at cabin pressure altitudes above:
      i. 12,500' MSL up to/including 14,000' unless the required minimum flight crew is provided with and uses supplemental oxygen for the part of the flight at those altitudes over 30 minutes
      ii. 14,000' unless the required min flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes
      iii. 15,000' unless each occupant of the aircraft is provided with supplemental oxygen
   B. No person may operate a civil aircraft of US registry with a pressurized cabin at flight altitudes above:
      i. FL 250 unless at least a 10-minute supply of supplemental oxygen, in addition to any oxygen required to satisfy the paragraph above, is available for each occupant of the aircraft for use in the event that a descent is necessitated by a loss of cabin pressure
      ii. FL 350, unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed (and that either supplies oxygen at all times or automatically whenever the cabin pressure exceeds 14,000' MSL)
         a. Exception: One pilot need not wear and use an oxygen mask while at or below FL 410 if there are two pilots at the controls and each pilot has a quick donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed
         b. Above FL 350: If for any reason at any time, one pilot leaves the controls the remaining pilot shall put on and use an oxygen mask until the other pilot has returned
3. **RM: Physiological Hazards** (RM: High altitude flight) AI.II.N.K2, AI.II.N.R1
   A. The human body functions normally from sea level to 12,000' MSL
      i. Brain oxygen saturation is at a level for normal function (Optimal functioning is 96% saturation)
         a. At 12,000', oxygen saturation is approx. 87%, which gets close to a performance affecting level

b. Above 12,000' oxygen saturation continues to decrease and affect performance

B. Hypoxia (Reduced Oxygen, or not enough oxygen) AI.II.N.K2a
 i. A state of oxygen deficiency in the blood, tissues, and cells sufficient to cause an impairment of functions
 ii. The concern is getting enough oxygen to the brain, since it is particularly vulnerable to deprivation
  a. Any reduction in mental function while flying can result in life-threatening errors
 iii. Types
  a. Hypoxic Hypoxia (Insufficient oxygen available to the lungs)
  b. Hypemic Hypoxia (The blood cannot transport enough oxygen to the tissues/cells)
  c. Stagnant Hypoxia (Oxygen rich blood isn't moving to the tissues)
  d. Histotoxic Hypoxia ("Histo" refers to tissues or cells, and "Toxic" means poison)
 iv. Symptoms AI.II.N.K2b
  a. Cyanosis; Headache; Delayed reactions/Impaired judgment; Euphoria; Visual Impairment; Drowsiness/Lightheaded or dizzy sensation; Tingling in fingers or toes and Numbness
   - Even with all these symptoms, hypoxia can cause a pilot to have a false sense of security
 v. Time of Useful Consciousness (TUC) AI.II.N.K2c
  a. Max time to make and carry out rational, lifesaving decisions at a given altitude
  b. > 10,000', symptoms increase in severity, and TUC rapidly decreases

Altitude	Time of Useful Consciousness
45,000 ft. MSL	9 to 15 seconds
40,000 ft. MSL	15 to 20 seconds
35,000 ft. MSL	30 to 60 seconds
30,000 ft. MSL	1 to 2 minutes
28,000 ft. MSL	2 ½ minutes to 3 minutes
25,000 ft. MSL	3 to 5 minutes
22,000 ft. MSL	5 to 10 minutes
20,000 ft. MSL	30 minutes or more

 vi. Treatment
  a. Flying at lower altitudes (emergency descent) and use supplemental oxygen
 vii. For more details, see II.A.2. Hypoxia

C. Vision Deteriorates with Altitude
 i. Sharp, clear vision requires significant oxygen, especially at night
  a. Unaided night vision depends on optimum function and sensitivity of the rods of the retina
   - Lack of oxygen to the rods (hypoxia) significantly reduces their sensitivity
   - Above 4,000', without supplemental oxygen, night vision measurably declines

D. Hyperventilation
 i. An increase in the rate and depth of breathing that exchanges gas in the lung beyond volumes necessary to maintain normal levels of oxygen and carbon dioxide
  a. Hyperventilation can occur as an early adaptive mechanism to hypoxia at altitude
  b. Hyperventilation and hypoxia symptoms are very difficult to distinguish
 ii. Treatment
  a. Breathe supplemental oxygen and slow the breathing rate
  b. Hypoxia and hyperventilation are treated the same

4. Types of Oxygen Systems AI.II.N.K3a

A. Continuous Flow
 i. Most common in GA planes
 ii. Usually for passengers and has a reservoir bag which collects oxygen from the system while exhaling
 iii. Ambient air is added to the oxygen during inhalation after the reservoir oxygen supply is depleted
 iv. Exhaled air is released into the cabin

B. Diluter Demand
 i. Supply oxygen only when the user inhales through the mask
 ii. Depending on the altitude, the regulator can provide 100% oxygen or mix the cabin air and oxygen
 iii. The mask provides a tight seal and can be used safely up to 40,000'

C. Pressure Demand

i. Similar to diluter demand, except oxygen is supplied under pressure at cabin altitudes above 34,000’
ii. Provide a positive pressure application of oxygen that allow the lungs to be pressurized with oxygen
iii. Safe at altitudes above 40,000’
iv. Some systems include the regulator on the mask to eliminate purging a long hose of air

5. **Aviator’s Breathing Oxygen** (Introduction to Aviation Physiology document) AI.II.N.K3b
   A. Aviator’s oxygen must meet a minimum purity requirement, excluding moisture content, of 99.5% and may not contain more than 0.005 mg of water vapor per liter
      i. Different limits are established for oxygen from different sources in recognition of the different ways oxygen is stored, dispensed, and used
      ii. Recommended to use aviator’s breathing oxygen all times, medical/industrial oxygen may not be safe
6. RM: **Care and Storage of High-Pressure Oxygen Bottles** AI.II.N.K3c, AI.II.N.R3
   A. If the airplane does not have a fixed installation, portable oxygen equipment must be accessible in flight
   B. Oxygen is usually stored in high pressure containers at 1,800 – 2,200 psi
      i. When the ambient temperature surrounding the cylinder decreases, pressure within will decrease
         a. This occurs because pressure varies directly with temperature if the volume of a gas remains constant
         b. A drop in the indicated pressure may be due to the container being stored in an unheated area of the aircraft, rather than depletion of the oxygen supply
      ii. High pressure containers should be marked with the psi tolerance before filling to that pressure
         a. The oxygen used should meet or exceed SAE AS8010, Aviation Breathing Oxygen Purity Standard
   C. RM: Be aware of the danger of fire when using oxygen AI.II.N.R4
      (RM: Combustion hazards in an oxygen rich environment)
      i. Materials that are nearly fireproof in ordinary air may be susceptible to combustion in oxygen
         a. Oils and greases may catch fire if exposed to pure oxygen and cannot be used in oxygen systems
      ii. Smoking during any kind of oxygen equipment use is prohibited
   D. Before each flight, thoroughly inspect and test all oxygen equipment
      i. Examine the equipment - available supply, operational check, and assure it is readily available
   E. To assure safety, periodic inspections and servicing should be done

RM: Use of Supplemental Oxygen AI.II.N.R2
The lesson as a whole is a discussion on supplemental oxygen risk management
Ensure understanding of the system’s operation, and oxygen requirements

Conclusion:
Brief review of the main points
The fundamental concept of cabin pressurization is that it is the compression of air in the airplane’s cabin to maintain a cabin altitude lower than the actual flight altitude. If your airplane is equipped with a pressurization system, you must know the normal and emergency operating procedures.

II.O. Pressurization

References: 14 CFR Part 91, AC 61-107, Airplane Flying Handbook (FAA-H-8083-3), AIM, POH/AFM

Objectives	The learner should develop knowledge of the elements related to high altitude operations and be able to explain the necessary elements as required in the ACS.
Key Elements	1. Regulations 2. Aviator's Oxygen 3. Decompression and Hypoxia
Elements	1. High-Altitude Flight Environment 2. Physiological Factors 3. Pressurization in Airplanes 4. Rapid Decompression
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands and can explain the elements involved with high altitude operations.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

So, you want to fly really high? It's not just that simple. A lot changes as the altitude increases.

Overview

Review Objectives and Elements/Key ideas

What

The required equipment, how it functions, the unique hazards and regulations associated with flying at high altitudes.

Why

There are many advantages to flying at high altitudes (jet engines are more efficient, weather and turbulence can be avoided, etc.). Many modern GA airplanes are being designed to operate in the high-altitude environment, therefore it is important that pilots be familiar with at least the basic operating principles.

How:

1. **High-Altitude Flight Environment**
   A. FAR 61.31(g) considers all flight operations conducted above 25,000' MSL to be high altitude, however many effects of higher altitudes can be felt well below 25,000'
2. **RM: Physiological Hazards** (RM: High altitude flight) AI.II.O.K2, AI.II.O.R1
   A. The human body functions normally from sea level to 12,000' MSL
      i. Brain oxygen saturation is at a level for normal function (Optimal functioning is 96% saturation)
         a. At 12,000', oxygen saturation is approx. 87%, which gets close to a performance affecting level
         b. Above 12,000' oxygen saturation continues to decrease and affect performance
   B. Hypoxia (Reduced Oxygen, or not enough oxygen) AI.II.O.K2a
      i. A state of oxygen deficiency in the blood, tissues, and cells sufficient to cause impairment of body functions
      ii. The concern is getting enough oxygen to the brain, since it is particularly vulnerable to deprivation
         a. Any reduction in mental function while flying can result in life-threatening errors
      iii. Types
         a. Hypoxic Hypoxia (Insufficient oxygen available to the lungs)
         b. Hypemic Hypoxia (The blood cannot transport enough oxygen to the tissues/cells)
         c. Stagnant Hypoxia (Oxygen rich blood isn't moving to the tissues)
         d. Histotoxic Hypoxia ("Histo" refers to tissues or cells, and "Toxic" means poison)
      iv. Symptoms of Hypoxia AI.II.O.K2b
         a. Cyanosis; Headache; Delayed reactions/Impaired judgment; Euphoria; Visual Impairment; Drowsiness, lightheaded or dizzy sensation; Tingling in fingers or toes, Numbness
            - Even with all these symptoms, hypoxia can cause a pilot to have a false sense of security
      v. Time of Useful Consciousness (TUC) AI.II.O.K2c
         a. Max time to make and carry out rational, lifesaving decisions at a given altitude
         b. > 10,000', symptoms increase in severity, and TUC rapidly decreases

Altitude	TUC
45,000 ft. MSL	9 to 15 seconds
40,000 ft. MSL	15 to 20 seconds
35,000 ft. MSL	30 to 60 seconds
30,000 ft. MSL	1 to 2 minutes
28,000 ft. MSL	2 ½ to 3 minutes
25,000 ft. MSL	3 to 5 minutes
22,000 ft. MSL	5 to 10 minutes
20,000 ft. MSL	30 minutes or more

vi. Treatment
   a. Flying at lower altitudes (emergency descent) and use supplemental oxygen
vii. For more details, see II.A.2. Hypoxia

C. Vision Deteriorate with Altitude
   i. Sharp, clear vision requires significant oxygen, especially at night
   ii. Unaided night vision depends on optimum function and sensitivity of the rods of the retina
      a. Lack of oxygen to the rods (hypoxia) significantly reduces their sensitivity
      b. Above 4,000', without supplemental oxygen, night vision measurably declines

D. Hyperventilation
   i. An increase in the rate and depth of breathing that exchanges gas in the lung beyond volumes necessary to maintain normal levels of oxygen and carbon dioxide
      a. Hyperventilation can occur as an early adaptive mechanism to hypoxia at altitude
      b. Hyperventilation and hypoxia symptoms are very difficult to distinguish
   ii. Treatment
      a. Breathe supplemental oxygen and slow the breathing rate
      b. Hypoxia and hyperventilation are treated the same

E. Trapped Gas
   i. Gases expand with any decrease in pressure – if you reduce the pressure, as you ascend to altitude, gases increase in volume, and then decrease in volume during descent
   ii. The body has several cavities that contain varying amounts of gas
      a. Most cavities can allow the gas to escape, but if the gas gets trapped it can result in pain
      b. Problem areas include middle ear, sinuses, teeth, and GI tract

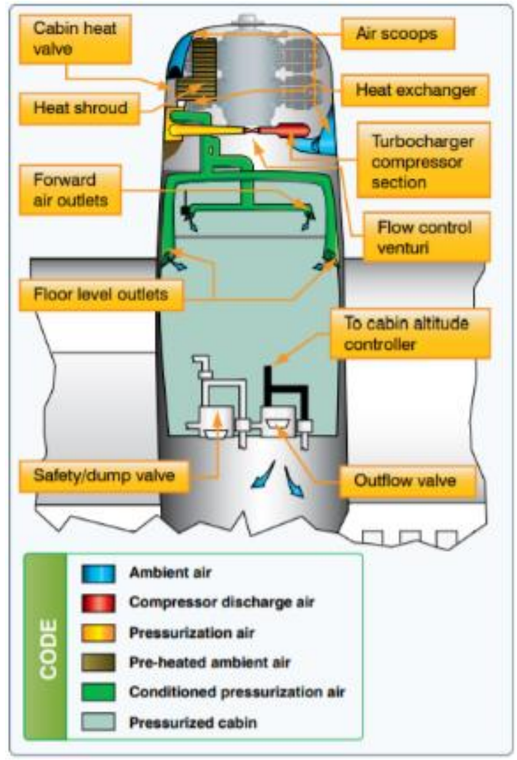
F. Nitrogen Absorption (Decompression Sickness - DCS)
   i. One of the more dangerous problems
      a. At sea level, the nitrogen inside the body and outside the body is in equilibrium
      b. When atmospheric pressure is reduced, the equilibrium is upset and nitrogen leaves the body
      c. If the nitrogen leaves too quickly, bubbles may form causing a variety of symptoms
   ii. Evolving and expanding gases in the body are known as decompression sickness. There are 2 groups:
      a. Trapped Gas: expanding or contracting gas in certain body cavities during altitude changes can result in abdominal pain, toothache, or pain in ears and sinuses if unable to equalize pressure changes
      b. Evolved Gas: When the pressure on the body drops sufficiently, nitrogen comes out of solution and forms bubbles which can have adverse effects on some body tissues
   iii. Scuba diving and Nitrogen
      a. Scuba diving results in a significant increase in the amount of nitrogen dissolved in the body
         - The deeper the dive, the greater the nitrogen
      b. After diving, if not enough time is allowed to eliminate excess nitrogen, DCS can occur as low as 5,000'
         - In normal conditions, most cases of DCS occur at altitudes of 25,000' or higher

3. Pressurization in Airplanes AI.II.O.K1

A. Cabin pressurization is the compression of air to maintain a cabin altitude lower than the flight altitude
   i. This removes the need for full-time use of supplemental oxygen
   ii. A cabin pressure altitude of approximately 8,000' is maintained and prevents rapid changes of cabin altitude that may be uncomfortable or cause injury to passengers/crew (prevents against hypoxia)
   iii. Differential Pressure – the difference in pressure between the pressure acting on one side of a wall and the pressure acting on the other side of the wall (the difference between cabin pressure and atmospheric pressure)
      a. The degree of pressurization is limited by several design factors
      b. Each fuselage is designed and rated to withstand a maximum differential pressure

B. How it Works

i. The cabin, flight and baggage compartments are incorporated into a sealed unit capable of containing air under a higher pressure than the outside atmospheric pressure
ii. Air is brought into the fuselage
   a. Turbine powered aircraft – bleed air from the engine compressor section is used to pressurize the cabin
   b. Piston-powered airplanes often use air supplied from each engine turbocharger
   c. Air is compressed, conditioned & sent to the fuselage



iii. Air is released from the fuselage through an outflow valve
   a. By regulating the air exiting the airplane, the outflow valve can maintain a constant pressure and allow for a constant inflow of air to the pressurized area
iv. The cabin pressure control system is what provides pressure regulation, pressure relief, vacuum relief, and the means for selecting the desired cabin altitude
   a. A cabin pressure regulator, an outflow valve, and a safety valve are used to accomplish these functions
      - Cabin Pressure Regulator – controls cabin pressure
         a Typically, a cabin pressure altitude of 8,000' is maintained at the maximum cruising altitude
            1. Lower altitudes maintain lower cabin pressures
         b Reaching the maximum differential pressure, any further increase in altitude results in a corresponding increase in cabin altitude
      - The flow of compressed air is regulated by an outflow valve which keeps pressure at the desired setting by releasing excess pressure into the atmosphere
         a The valve will open and close to maintain the desired pressurization
      - The Safety Valve is a combination of a pressure relief, vacuum relief, and dump valve
         a Pressure Relief prevents the cabin pressure from exceeding a predetermined differential pressure by allowing pressure to be released into the atmosphere if necessary
         b Vacuum Relief prevents ambient pressure from exceeding cabin pressure by allowing external air to enter when ambient pressure exceeds cabin pressure
         c The Dump Valve dumps cabin air to the atmosphere (switch in the flight deck)
            1. This equalizes the cabin pressure to the outside air pressure
v. Instruments
   a. Cabin differential pressure gauge indicates the difference between inside and outside pressure
   b. Cabin Altimeter shows the altitude inside the airplane
      - Differential pressure gauge and cabin altimeter can be combined into one instrument
   c. Cabin Rate of Climb/Descent
      - This shows how quickly the cabin altitude is changing during a climb or descent
vi. RM: Malfunctions/Failure Modes AI.II.O.R2
   a. Reference the POH checklist
   b. Be prepared for reduced pressurization or decompression
      - Potential for supplemental oxygen and/or emergency descent

4. Rapid Decompression AI.II.O.K2d

A. Decompression is the inability of the pressurization system to maintain its designed pressure differential
   i. This can be caused by a malfunction in the pressurization system or structural damage to the plane
      a. If the turbo charger fails, not only will the airplane descend, but pressurization will be lost
B. Two categories of decompression
   i. Explosive Decompression: A change in cabin pressure faster than the lungs can decompress (
      a. < 0.5 seconds. Possibly leading to lung damage
   ii. Rapid Decompression: A change in cabin pressure where the lungs can decompress faster than the cabin
      a. No likelihood of lung damage
C. Indications of a Rapid or Explosive Decompression
   i. During explosive decompression, there may be noise and one may feel dazed for a second
   ii. During most decompressions, the cabin will fill with fog, dust, flying debris
      a. Fog is the result of the rapid change in temperature and change of relative humidity
   iii. Air will rush from the mouth and nose due to the escape of air from the lungs
      a. Normally, the ears clear automatically
D. Time of Useful Consciousness (TUC)
   i. Rapid decompression reduces TUC because oxygen is exhaled rapidly, reducing pressure on the body
   ii. This decreases partial pressure of oxygen in the blood and reduces TUC by 1/3 to ¼ its normal time
      a. Oxygen mask should be worn at very high altitudes (35,000’ or higher)
         - Recommended to select 100% oxygen
E. Primary Danger of Decompression is Hypoxia
   i. Quick, proper utilization of oxygen equipment is necessary to avoid unconsciousness
   ii. Another potential danger is decompression sickness, as discussed above
F. Supplemental oxygen and a rapid descent from altitude is necessary to minimize the problems associated with decompression

Conclusion:
Brief review of the main points
The fundamental concept of cabin pressurization is that it is the compression of air in the airplane’s cabin to maintain a cabin altitude lower than the actual flight altitude. If your airplane is equipped with a pressurization system, you must know the normal and emergency operating procedures.

PREFLIGHT PREPARATION

III.A. Pilot Qualifications

References: 14 CFR parts 23, 43, 61, 67, 91, Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The learner should develop knowledge of the elements related to certificates and documents. Knowledge will be gained regarding the necessary requirements for each license, medical certificate, and recent flight experience.
Elements	1. Medical Certificates & Basic Med 2. Certification & Training Requirements 3. Logbook Entries & Records 4. Privileges and Limitations 5. Pilot Currency 6. Required Documents
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner knows what to expect with each license issued and understands the requirements in logging time as well as obtaining a medical.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Understanding what is required with each certificate and document that a pilot may obtain is essential to obtaining that certificate.

Overview

Review Objectives and Elements/Key ideas

What

Certificates and Documents cover the knowledge necessary to obtain and maintain the recreational, private, and commercial license. This also covers medical certificates and required logbook entries.

Why

Each certificate and medical has different rules. The pilot should know what is required to obtain and maintain the desired certificate as well as the privileges and limitations associated with each certificate. It is also necessary to know how medical certificates work and what training must be logged.

How:

1. **Medical Certificates** (FAR 61.23) **& Basic Med** AI.III.A.K3
   A. Medical Certificates
      i. What is it?
         a. Routine medical exam from an FAA authorized Aviation Medical Examiner (AME)
         b. 3 different classes depending on what you intend to fly – 1st, 2nd, 3rd class
            - Exam requirements increase with increased responsibilities
      ii. Who Needs it? (More details / requirements in FAR 61.23)
         a. A First-Class Medical Certificate is required when:
            - Exercising the PIC privileges of an airline transport pilot certificate
            - Exercising the SIC privileges of an airline transport pilot certificate that requires 3 or more pilots, or when serving as a required flight crewmember under Part 121 and 60 years old or older
         b. A Second-Class Medical Certificate is required when exercising:
            - Second-in-command privileges of an airline transport pilot certificate under Part 121
            - Privileges of a commercial pilot certificate
         c. A Third-Class Medical Certificate is required when:
            - Exercising the privileges of a Private, Recreational, or Student pilot certificate
            - Exercising the privileges of CFI certificate as PIC or required crewmember
            - Taking a practical test for recreational, private, commercial, ATP, CFI certificates
            - When performing the duties as an Examiner in an aircraft when administering a practical test or proficiency check
         d. A medical is not required when:
            - Exercising the privileges of a flight instructor certificate if the person is not acting as PIC or serving as a required flight crewmember
            - Exercising the privileges of a ground instructor certificate
            - When a military pilot of the US Armed Forces can show evidence of an up-to-date medical examination authorizing pilot flight status issued by the US Armed Forces and

        a The flight does not require higher than a 3rd class medical certificate
        b The flight conducted is a domestic flight within US airspace

iii. Class and Duration (FAR 61.23(d))
   a. First Class
      - Under 40 on the date of the examination - Expires at the end of the last day of the:
        a 12th month for 1st class activities
        b 12th month for 2nd class activities
        c 60th month for 3rd class activities (under 40 years old)
      - 40 or older on the date of the examination - Expires at the end of the last day of the:
        a 6th month for 1st class activities
        b 12th month for 2nd class activities
        c 24th month for 3rd class activities (over 40 years old)
   b. Second Class
      - When exercising the privileges of Commercial certificate
      - Under 40 on the date of the examination - Expires at the end of the last day of the:
        a 12th month for 2nd class activities
        b 60th month for 3rd class activities
      - 40 or older on the date of the examination - Expires at the end of the last day of the:
        a 12th month for 2nd class activities
        b 24th month for 3rd class activities
   c. Third Class
      - When exercising the privileges of a CFI, Private, Recreational, Student certificate, etc.
      - Under 40 on the date of the examination - Expires at the end of the last day of the:
        a 60th month
      - 40 or older on the date of the examination - Expires at the end of the last day of the:
        a 24th month

iv. How to find an AME
   a. FAA Directory of AMEs can be found at:
      - FSDOs, FSSs, FAA Offices
        a Online: FAA.gov Find an AME

v. Once you have a medical, how is it regulated?
   a. FAR 61.53 (Prohibition on operations during medical deficiency) prohibits flying if you:
      - Know of any medical condition that would prevent you from obtaining a medical
      - Are taking medication/receiving treatment that would prevent you from obtaining a medical
   b. Once a medical is obtained, it is self-regulating
      - Can you fly with an injury, possible sickness?
        a It's the pilot's judgment (be safe, and conservative)

vi. Medical Certificate with a Possible Medical Deficiency
   a. Even with a medical deficiency, a medical certificate may be able to be issued
      - Students with physical limitations may be issued a "student privileges only" certificate
        a Special equipment may need to be installed in the airplane
        b Some disabilities require limitations on the certificate
      - When all the knowledge, experience, and proficiency requirements have been met, and the student can demonstrate the ability to operate with the normal level of safety, a "statement of demonstrated ability" (SODA) will be issued
        a Remains valid as long as the impairment doesn't worsen
      - Obtain assistance from the local FSDO as well as an AME

b. The FAA specifies 15 medical conditions that are disqualifying (listed here)
   - If ever diagnosed with one of these conditions, the only way to receive a medical certificate is through a Special Issuance Authorization (FAR 67.401)

c. With few exceptions, all disqualifying medical conditions may be considered for special issuance
   - Chances are good if you can present satisfactory documentation that the condition is stable

B. BasicMed & Using a Driver's License – FAR 61.23(c)

i. Overview
   a. A way to operate without an FAA medical certificate
   b. A pilot is required to complete a medical education course, undergo a medical examination every four years, and comply with aircraft and operating restrictions
   c. FAA BasicMed Info; FAA BasicMed FAQ

ii. Applicable when:
   a. Exercising the privileges of a student, recreational or private pilot certificate if the flight is conducted under FAR 61.113(i)
   b. Exercising the privileges of a flight instructor certificate and acting as PIC or a required crewmember if the flight is conducted under FAR 61.113(i)

iii. A person using their driver's license must:
   a. Comply with all medical requirements associated with the license
   b. Have held a medical certificate after July 14, 2006
   c. Have completed the medical education course in the last 24 months
   d. Have received a medical exam in the past 48 months using the directed exam checklist
   e. Have not had the most recently held medical certificate revoked, suspended, or withdrawn
   f. Be under the care of a physician if diagnosed with a condition that may affect flight abilities

iv. FAR 61.113(i) requires:
   a. Aircraft: Authorized for no more than 6 occupants, Max takeoff weight of 6,000 lbs.
   b. Flight: In the US, not more than 18,000' and 250 knots, not for compensation/hire
   c. Pilot: Has medical exam checklist and certificate of course completion in logbook

2. Certification & Training Requirements AI.III.A.K1

A. Sport Pilot Certificate (FAR 61.313)

i. Log at least
   a. 20 hours of flight time
      - At least 15 hours from an authorized instructor in a single-engine airplane
      - AT least 5 hours solo flight training
   b. Flight time must include at least
      - 2 hours of cross-country flight training
      - 10 takeoffs & landings to a full stop
      - 1 solo cross-country flight at least 75 nm total, with a full-stop landing at a min of 2 points
      - 2 hours of flight training with an instructor in preparation for the practical test

B. Recreational Certificate (FAR 61.99)

i. Must receive and log at least 30 hours of flight time that includes at least:
   a. 15 hours from an authorized instructor in the areas listed in FAR 61.98 that consists of at least:
      - 2 hours of training enroute to an airport more than 25 nm from the airport where the applicant normally trains and includes at least 3 takeoffs and landings at the destination
      - 3 hours of flight training for the rating sought in preparation of the practical test (within the preceding 2 calendar months of the test)
      - 3 hours of solo flying

C. Student Pilot Certificate

i. As of April 2016, the medical certificate is no longer used as the student pilot certificate
ii. Eligibility - FAR 61.83
   a. At least 16 years old
iii. Application - FAR 61.85
   a. Submit an application to a Flight Standards District Office, a designated pilot examiner, an airman certification representative associated with a pilot school, a flight instructor, or other person authorized by the Administrator
   b. The FAA estimates it will take approx. 3 weeks to approve and return the new plastic student pilot certificates to applicants by mail
iv. Here's more info than you'll ever need: Student Pilot Application Requirements

D. Private Certificate (FAR 61.109)
   i. For an airplane single engine rating
      a. Must log at least 40 hours of flight time
         - At least 20 of which must be flight instruction from an authorized instructor
         - At least 10 hours must be solo flight including:
            a 5 hours of solo cross-country time
            b One solo cross-country flight of at least 150 nm total distance with full stop landings at a minimum of 3 points and one segment of the flight consisting of a straight-line distance of at least 50 nm between the T/O and LDG locations
            c 3 takeoffs and landings to a full stop at an airport with an operating control tower
      b. The training must include at least:
         - 3 hours cross-country flight training in a single engine plane
         - 3 hours of night flight training which includes:
            a Once cross-country flight over 100 nm total distance
            b 10 takeoffs and landings to a full stop at an airport
         - 3 hours of flight training on the control/maneuvering solely by reference to instruments
         - 3 hours of flight training in prep for the practical test (within the preceding 2 calendar months from the month of the test)
   ii. For an airplane multiengine rating the same requirements apply but in a multiengine airplane
      a. Except, the 10 hours of solo time must be in an *airplane* (does not have to be multiengine)

E. Commercial Certificate (FAR 61.129)
   i. Recent Changes
      a. Effective April 24, 2018, the FAA issued FAA Notice 8900.463 and made a change to the Commercial Pilot-Airplane ACS to reflect that the practical test for a single-engine rating no longer requires the applicant to supply a complex airplane.
         - The FAA has determined that any airplane may be used to accomplish the tasks prescribed in the initial commercial pilot with an airplane single-engine rating practical test, provided that airplane is capable of accomplishing all areas of operation required for the practical test and is the appropriate category and class for the rating sought. Therefore, the airplane used for the practical test must still meet the requirements specified in FAR 61.45.
         - There is no change to the complex airplane training and endorsement requirements of FAR 61.31(e) or to the commercial pilot aeronautical experience requirements of FAR 61.129(a)(3)(ii) or Part 141 appendix D
      b. Effective August 27, 2018, the FAA has approved the use of Technically Advanced Aircraft (TAA) to satisfy the 10 hours of training required for the Commercial Airplane, Single Engine Rating in FAR 61.129
   ii. For an airplane single engine rating
      a. Must log at least 250 hours of flight time as a pilot that consists of at least:

- 100 hours in powered aircraft, 50 hours of which must be in airplanes
- 100 hours of PIC flight time, which includes at least:
  - a 50 hours in airplanes; and
  - b 50 hours in cross-country flight of which at least 10 hours must be in airplanes
- 20 hours of training in the areas of operation (61.127(b)(1)) that includes at least:
  - a 10 hours of instrument training; at least 5 hours must be in a single engine airplane
  - b 10 hours of training in a complex aircraft, a turbine powered aircraft, or a technically advanced aircraft (TAA) that meets the requirements in FAR 61.129(j), or any combination of these aircraft.
    1. The TAA must be equipped with an electronically advanced avionics system that includes the following:
       - a. An electronic PFD that includes, at a minimum, an airspeed indicator, turn coordinator, attitude indicator, heading indicator, altimeter,
       - b. An electronic MFD that includes, at a minimum, a moving map using GPS navigation with the aircraft position displayed
       - c. A two-axis autopilot integrated with the navigation and heading guidance system
       - d. The display elements of the PFD and MFD must be continuously visible
  - c One 2-hour cross-country flight in a single engine airplane in day VFR conditions
    1. The total straight-line distance must be more than 100 nm from the original point of departure
  - d One 2-hour cross-country flight in a single engine airplane in night VFR conditions
    1. The total straight-line distance must be more than 100 nm from the original point of departure
  - e 3 hours in a single engine airplane with an instructor in preparation for the practical test within the preceding 2 calendar months from the month of the test
- 10 hours of solo flight time (or flight time performing the duties of PIC) in a single engine airplane on the areas of operation in FAR 61.127(b)(1) which includes at least:
  - a One cross-country flight not less than 300 nm total distance with landings at a minimum of 3 points, one of which is a straight-line distance of at least 250 nm from the original departure point
  - b 5 hours in night VFR conditions with 10 takeoffs and landings at an airport with an operating control tower

iii. For an airplane multiengine rating (differences to the single engine rating are shown in red)

- 100 hours in powered aircraft, 50 hours of which must be in airplanes
- 100 hours of PIC flight time, which includes at least:
  - a 50 hours in airplanes; and
  - b 50 hours in cross-country flight of which at least 10 hours must be in airplanes
- 20 hours of training in the areas of operation (61.127(b)(1)) that includes at least:
  - a 10 hours of instrument training; at least 5 hours must be in a multiengine airplane
  - b 10 hours of training in a multi-engine complex or turbine powered airplane
  - c One 2-hour cross-country flight in a multiengine airplane in daytime conditions
    1. The total straight-line distance must be more than 100 nm from the original departure point
  - d One 2-hour cross-country flight in a multiengine airplane in nighttime conditions
    1. The total straight-line distance must be more than 100 nm from the original departure point
  - e 3 hours in a multiengine airplane with an instructor in preparation for the practical test within the preceding 2 calendar months from the month of the test
- 10 hours of solo flight time (or flight time performing the duties of PIC) in a multiengine airplane on

the areas of operation in FAR 61.127(b)(2) which includes at least:
- a One cross-country flight not less than 300 nm total distance with landings at a minimum of 3 points, one of which is a straight-line distance of at least 250 nm from the original departure point
- b 5 hours in night VFR conditions with 10 takeoffs and landings at an airport with an operating control tower

3. Logbook Entries & Records AI.III.A.K1

A. Required Logbook Entries (FAR 61.51 & 61.189)
- i. 61.189: A flight instructor must sign the logbook of each person they have given flight or ground training
- ii. 61.51: Must document and record training and aeronautical experience used to meet the requirements for a certificate, rating, or review
- iii. In the logbook, you must enter:
  - a. General,
    - Date, Total flight/lesson time; location of departure/arrival (for a simulator, the location where the lesson occurred); type and identification of aircraft, simulator, or training device; and the name of the safety pilot (if necessary)
  - b. Type of pilot experience or training
    - Solo, PIC, SIC, Flight and ground training received, training in a simulator or flight training device
  - c. Conditions of Flight
    - Day/Night, Actual Instrument, Simulated Instrument in flight or a simulator /FTD
- iv. FAR 61.51 also specifies the conditions for types of flight time (i.e., PIC time, instrument time)

B. Flight Instructor Records (FAR 61.189)
- i. Must maintain a record in a logbook or a separate document that contains the following:
  - a. Name of each person endorsed for solo flight privileges, and the date of the endorsement
  - b. Name of each person endorsed for a knowledge or practical test, with the kind of test, date, results
  - c. Must retain the records required for at least 3 years

4. Privileges and Limitations AI.III.A.K2

A. Sport – FAR 61. 89(c) & 61.315
- i. Student Pilot seeking a Sport Certificate (61.89(c))
  - a. Must comply with the Student pilot provisions above, and may not as PIC
    - Of an aircraft other than a light-sport
    - At night
    - > 10,000' MSL or 2,000' AGL, whichever is higher
    - In Class B, C, and D airspace, at an airport in Class B, C, or D airspace, and to/from/through/on an airport with an operational control tower without receiving FAR 61.94 ground & flight training
    - Of a light-sport aircraft without the ground & flight training and endorsements in 61.327(a) & (b)
- ii. Sport Pilot (61.315)
  - a. May act as PIC of a light-sport, except for the limitations in bullet c., below
  - b. May split the operating expenses of a flight with a passengers (fuel, oil, airport expenses, rental fees)
  - c. May not act as PIC of a light-sport aircraft:
    - Carrying a passenger or property for hire
    - For compensation or hire
    - In furtherance of a business
    - Carrying more than 1 passenger
    - At night
    - In Class A, B, C, or D airspace
    - At an airport in Class B, C, or D airspace

- To, from, through, or at an airport with an operational control tower without meeting the 61.325 requirements
- Outside the US, unless you have permission from the country
- To demonstrate the aircraft in flight to a buyer if you are a salesperson
- In a passenger-carrying airlift sponsored by a charitable organization
- > 10,000' MSL or 2,000' AGL, whichever is higher
- When flight or surface visibility is < 3 statute miles
- Without visual reference to the surface
- If the aircraft:
  - a Has a V_H > 87 knots CAS (unless you've met the requirements of 61.327(b))
  - b Has a V_H less than or equal to 87 knots CAS *unless you've met the requirements of 61.327(a), or logged flight time as PIC before April 2, 2010)
- Contrary to any operating limitation on the airworthiness certificate
- Contrary to any limit on your pilot certificate/medical certificate or any other limit/endorsement
- Contrary to any restriction or limitation on your US driver's license
- While towing an object
- As a pilot flight crewmember on any aircraft for which more than 1 pilot is required

B. Recreational Certificate (FAR 61.101)

i. A person who holds a recreational pilot certificate may:

a. Carry no more than one passenger; and
   - Not pay less than the pro rata share of the operating expenses of a flight with a passenger, provided the expenses involve only fuel, oil, airport expenses, or aircraft rental fees

b. Act as PIC on a flight within 50 nm from the departure airport, if that person has:
   - Received ground/flight training as specified in the FARs, been found proficient to make the trip, and received an endorsement permitting flight within 50 nm from the departure airport

c. Act as PIC on a flight exceeding 50 nm from the departure airport, if that person has:
   - Received ground/flight training as specified in the FARs, been found proficient, and received an endorsement for the cross-country training requirements

d. Act as PIC in Class B, C, and D airspace, if that person has:
   - Received ground/flight training as specified in the FARs, been found proficient, and received an endorsement

ii. A person who holds a recreational pilot certificate may NOT act as PIC of an aircraft:

a. For more than 4 occupants
b. With more than one powerplant
c. With a powerplant of more than 180 horsepower
d. With retractable landing gear
e. That is classified as a multiengine airplane
f. For compensation on hire (with or without passengers or property)
g. In furtherance of a business
h. Between sunset and sunrise
i. In class A, B, C, and D airspace, at an airport in class B, C, or D airspace, or to, from, through, or at an airport having an operation control tower
j. Above 10,000' MSL or 2,000' AGL (whichever is higher)
k. When flight or surface visibility is less than 3 statute miles (sm)
l. Without visual reference to the surface
m. On a flight outside the US
n. To demonstrate the aircraft in flight as an aircraft salesperson to a prospective buyer

        o. That is used in a passenger carrying airlift and sponsored by a charitable organization
        p. That is towing any object
    iii. A recreational pilot may not act as a flight crewmember on an aircraft with a type certificate requiring more than one pilot except when:
        a. Receiving flight training, and no one other than the required flight crewmember is onboard
    iv. A recreational pilot with < 400 flight hours, who has not logged PIC in an aircraft within the preceding 180 days shall not act as PIC until receiving flight training and an endorsement certifying PIC proficiency

C. Student – FAR 61.89
    i. May not act as PIC of an aircraft
        a. Carrying a passengers
        b. Carrying property for compensation or hire
        c. In furtherance of a business
        d. On an international flight (exceptions in FAR 61.89(
        e. With a flight or surface visibility of less than 3 statute miles during the day or 5 SM at night
        f. When the flight cannot be made with visual reference to the surface
        g. In a manner contrary to any limitations placed in the pilot's logbook by an authorized instructor
        h. May not act as a required crewmember on any aircraft that more than 1 pilot is required

D. Private Pilot (FAR 61.113)
    i. May not act as PIC of an aircraft carrying passengers or property for compensation or hire
    ii. May act as PIC for compensation/hire if incidental to the business and no passengers or property
    iii. May not pay less than the pro rata share of the operating expenses of a flight provided the expenses involve only fuel, oil, airport expenditures, or rental fees
    iv. May be reimbursed for operating expenses directly related to search and location operations
    v. May act as PIC for a charitable, nonprofit, or community event (FAR 91.146)
    vi. May be reimbursed for operating expenses directly related to search and rescue
    vii. May demo an aircraft to a potential buyer if have over 200 hours and are an aircraft salesman
    viii. May act as PIC of an aircraft towing a glider (under FAR 61.69)
    ix. May act as PIC to conduct a production flight test in a light-sport aircraft intended for light sport certification provided that:
        a. Aircraft is a powered parachute or weight shift control aircraft
        b. The person has at least 100 hours of PIC time in the category and class of aircraft flown
        c. The person is familiar with processes/procedures applicable to flight testing

E. Commercial Privileges and Limitations (FAR 61.133)
    i. Privileges
        a. May act as PIC of an aircraft carrying persons or property for compensation/hire
        b. May act as PIC of an aircraft for compensation/hire
    ii. Limitations
        a. Without an instrument rating in the same category and class, the carriage of passengers for hire on cross-country flights over 50 nm or at night is prohibited

F. Flight Instructor Privileges – FAR 61.193
    i. Authorized within the limits of their certificate to train and issue endorsements required for a(n):
        a. Student pilot certificate
        b. Pilot certificate
        c. Flight instructor certificate
        d. Ground instructor certificate
        e. Aircraft rating
        f. Instrument rating
        g. Flight review, operating privilege, or recency of experience requirement of part 61

h. Practical test
i. Knowledge test

ii. Authorized to
   a. Accept an application for a student pilot certificate
      - Or, for an applicant who holds a pilot certificate (other than student pilot) issued under part 61 and meets the flight review requirements in 61.56, a remote pilot certificate with a small UAS rating
   b. Verify the identity of the applicant
   c. Verify that an applicant for a student pilot certificate meets the eligibility requirements in FAR 61.83
      - Or an applicant for a remote certificate with a small UAS rating meet the requirements in 107.61

G. Flight Instructor Limitations & Qualifications – FAR 61.195

Numerous details and exceptions to the rules described in this FAR. Follow the link for more detail

i. Hours of Training
   a. May not conduct more than 8 hours of flight training in any 24-consecutive-hour period
ii. Aircraft Ratings
   a. May not conduct flight training in any aircraft (instrument rating exception below), unless they:
      - Hold a flight instructor certificate with the applicable category and class rating
      - Hold a pilot certificate with the applicable category and class rating
      - Meet the requirements of 61.195(e) Training in an Aircraft that Requires a Type Rating
iii. Instrument Rating
   a. Must hold an instrument rating appropriate to the aircraft used for the training, and
      - Meet the Aircraft Ratings requirements above, or
      - Hold a commercial or ATP certificate with the appropriate category and class ratings for the aircraft the instrument training is being conducted in, provided the pilot receiving training has the category & class ratings on their certificate
   b. If the training is in a multiengine airplane, the CFI must hold an instrument rating appropriate to the aircraft used and meet the Aircraft Ratings requirements above
iv. First-Time Flight Instructor Applicants
   a. Initial applicant ground training requires an instructor who:
      - Has held a ground/flight instructor certificate with the appropriate rating for at least 24 calendar months and has given at least 40 hours of ground training, or
      - Holds a ground or flight instructor certificate with the appropriate rating, and has given at least 100 hours of ground training in an FAA-approved course
   b. Initial applicant training requires a CFI who:
      - Holds the appropriate flight instructor certificate & rating
      - Has held a flight instructor certificate for at least 24 months
      - Has given at least 200 hours of flight training as an instructor
   c. Flight instructor at an FAA-approved course for the issuance of the flight instructor rating must
      - Hold a flight instructor certificate with the appropriate rating and pass the required initial and recurrent proficiency tests, and
         a Meet the requirements in b. (above), or
         b Have trained and endorsed at least 5 applicants for a practical test with at least an 80% first attempt pass rate, and given at least 400 hours of flight training
v. Training for Flight Solely by Reference to the Instruments
   a. Instructor must hold a flight instructor certificate with the applicable category & class rating, or
   b. Hold an instrument rating appropriate to the aircraft used on their CFI certificate, and hold a commercial or ATP certificate with the appropriate category and class ratings for the aircraft being used
      - Provided the pilot receiving training holds a pilot certificate with category & class ratings

appropriate to the aircraft being used

vi. Self-Endorsements
   a. Can't do it

vii. Limitations on Endorsements
   a. A CFI may not endorse a:
      - Student pilot's logbook for solo flight privileges, unless they have
         a Given the student the flight training required for solo flight privileges
         b Determined the student is prepared to conduct the flight safely, subject to any limitations
      - Student pilot's logbook for a solo cross-country flight unless the CFI has determined the flight preparation, planning, equipment, and proposed procedures are adequate for the flight
      - Student pilot's logbook for a solo flight in Class B airspace/at an airport in Class B unless they CFI
         a Has given the student ground & flight training in that Class B airspace/at the airport and
         b Determined the student is proficient to operate safely
      - Recreational pilot's logbook, unless the CFI has
         a Given the pilot the required FAR ground & flight training
         b Determine they are proficient to operate the aircraft safely
      - Logbook of a pilot for a flight review/IPC unless they conducted the review per 61.56(a)/61.57(d)

viii. Training in an Aircraft Requiring a Type Rating
   a. May not give flight instruction, including instrument training, in an aircraft that requires the PIC to hold a type rating unless the CFI holds a type rating for the airplane

ix. Position in Aircraft & Required Pilot Stations
   a. Aircraft must comply with 91.109
      - Must have dual controls (exceptions), safety pilot requirements, etc.
   b. Aircraft must have at least 2 pilot stations and be of the same category, class, and type, if appropriate, that applies to the certificate or rating sought
   c. For single place aircraft, the pre-solo training must have been done in an aircraft with 2 pilot stations and is of the same category, class, and type, if appropriate

5. Pilot Currency (FAR 61.57) AI.III.A.K1

A. Pilot in Command
   a. To carry passengers, a pilot must have made 3 takeoffs and landings within the preceding 90 days, and:
      - Acted as the sole manipulator of the flight controls in the same category, class, type aircraft
      - Tailwheel landings must be to a full stop

ii. To carry passengers 1 hour after sunset to 1 hour before sunrise, a pilot must have 3 takeoffs and landings within the preceding 90 days to a full stop during that time period, and:
   a. Acted as the sole manipulator of the flight controls in the same category, class, type aircraft

ii. FAR 61.57(c) & (d) - To act as PIC under IFR or weather conditions less than VFR minimums, within the preceding 6 months (preceding the month of the flight), you must have performed and logged at least:
   a. 6 instrument approaches, holding procedures, and intercepting/tracking courses
   b. If the pilot has failed to meet the instrument experience requirements (above) for more than 6 calendar months, currency may only be reestablished through an instrument proficiency check (IPC)
      - An IPC must consist of the areas of operation and instrument tasks required in the instrument rating practical test standards
      - The IPC must be given by an examiner, a company check pilot, an authorized instructor, or a person approved by the Administrator to conduct instrument practical tests

B. Flight Reviews (FAR 61.56)

i. No person may act as PIC unless, within the preceding 24 calendar months he has:
   a. Accomplished a flight review and received a log book endorsement certifying it was completed

    b. Flight review must be given by an authorized instructor
  ii. Consists of a MINIMUM of 1 hour of flight training and 1 hour of ground training and must include:
    a. A review of the current general operating rules and flight rules of Part 91 and a review of those maneuvers and procedures necessary for to demonstrate the safe exercise of the certificate
  iii. A flight review is not necessary, if in the past 24 calendar months, the pilot has passed any of the following:
    a. A pilot proficiency check or practical test for a pilot certificate, rating, or operating privilege
    b. A practical test for the issuance of a flight instructor certificate, an additional rating on a flight instructor certificate, renewal of a flight instructor certificate, or reinstatement of a flight instructor certificate
  iv. If one or more phase of an FAA sponsored pilot proficiency award program has been accomplished a flight review is not required
  iii. A student pilot undergoing training for a certificate and who has a current solo flight endorsement does not need a flight review

B. RM: Proficiency versus Currency — AI.III.A.R1
  i. Currency is the minimum required by law to legally fly
    a. Although legal, more practice may be needed to be proficient and safe
  ii. Proficiency is a level of understanding and ability that creates a safe and competent pilot
    a. Just because you are current does not mean you are proficient
    b. Ensure proficiency and competency in all aspects
      - Come up with a plan to ensure proficiency
        a Get more training, fly more consistently, fly with a CFI if proficiency is lacking
    c. Even in the air, your mistakes can affect others

C. RM: Flying Unfamiliar Aircraft — AI.III.A.R2
  i. Ensure proficiency in new or unfamiliar aircraft, systems, or avionics setup
    a. Just because you are certified to fly a specific aircraft, doesn't mean you're proficient or safe
    b. Get checked out by a CFI, study the POH/manual, etc.

6. Required Documents — AI.III.A.K4

A. FAR 61.3 Requirement for Certificates, Ratings, and Authorizations
  i. Pilot Certificate
  ii. Government Issued Photo Identification
  iii. Medical Certificate
  iv. Flight Instructor Certificate (if exercising privileges)

B. FAR 61.51(i) Presentation of Documents
  i. Must present pilot certificate, medical, logbook, or any other record required by part 61 upon request by
    a. The administrator, Authorized NTSB representative, Federal, State, or local law enforcement officer
  ii. A student pilot must carry the following on solo cross-country flights as evidence or required instructor clearances & endorsements:
    a. Pilot logbook
    b. Student pilot certificate
    c. Any other certificate required by Part 61
  iii. Sport pilot must carry
    a. Their logbook or other evidence of required instructor endorsements on all flights
  iv. Recreational pilot must carry:
    a. Logbook with the required instructor endorsements on all solo flights:
      - That exceed 50 nm from the airport at which the training was received
      - Within airspace requiring communication with ATC
      - Conducted between sunset & sunrise, or
      - In an aircraft for which the pilot doesn't hold an appropriate category or class rating
  v. Instructor with a sport pilot rating must carry:

a. Logbook or other evidence of required instructor endorsements when providing flight training

Conclusion:
Brief review of the main points
Each certificate and medical has different rules. It is therefore important to know what is required to obtain and maintain the desired certificate as well as the privileges and limitations associated with it. It is also necessary to know how medical certificates work and what training must be logged.

III.B. Airworthiness Requirements - General Overview

References: 14 CFR part 23, 39, 43, 91, Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Sample Type Certificate, Sample MEL

Objectives	The learner should exhibit knowledge of the elements regarding airworthiness requirements as necessary based on their respective ACS.
Key Elements	1. CFR 91.205 – Required Instruments 2. CFR 91.213(d) – Deferral without MEL 3. Required Inspections
Elements	1. Inoperative Equipment Before a Flight 2. Airworthiness 3. Obtaining a Special Flight Permit 4. Appropriate Record Keeping 5. Preventive Maintenance 6. Inoperative Equipment in Flight
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner can explain, and when necessary, locate, the elements and documents related to airworthiness requirements.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Just as you would never scuba dive without your regulator operating properly or sky dive without the rip cord functioning, you should never fly an airplane without essential equipment working properly.

Overview

Review Objectives and Elements/Key ideas

What

Airworthiness requirements are the basis for deciding whether an aircraft is worthy of safe flight. They are what must be met to ensure an aircraft is safe and therefore legal to fly.

Why:

For an airplane to be airworthy certain documents must be on board and current, certain inspections must be completed, and certain instruments must be functioning, otherwise the airplane is unfit for flight and therefore unairworthy or illegal to fly. An unairworthy aircraft cannot be flown without a special flight permit.

How:

1. **RM: Inoperative Equipment Before Flight** AI.III.B.R1
   - A. Equipment requirements are designed for everyone's safety
     - i. Without them, individual pilots would be left to make subjective safety decisions
   - B. The following procedures describe the process for handling inoperative equipment found before flight
     - i. These are minimum requirements to be legal to fly
     - ii. Just because it's legal, doesn't mean it's safe
     - iii. If you're not comfortable with the state of the aircraft, don't fly it
       - a. Set personal equipment minimums as desired
2. **Airworthiness:** Required Equipment, Inspections, Documents, & Airworthiness Certificates
   - A. Airworthiness without an MEL (Required Instruments and Equipment)
     - i. Widely used by most pilots due to the simplicity and minimal paperwork
     - ii. When inoperative equipment is found prior to flight, decide whether to:
       - a. Cancel the flight
       - b. Obtain maintenance prior to the flight, or
       - c. Defer the item or equipment - 91.213(d) AI.III.B.K3d
         - To defer, it must not be required by the documents discussed below in part iii. a, b, c, d
       - d. If the item is not required, it can be deferred. Inoperative equipment/instruments are either:
         - Removed from the aircraft and the cockpit control must be placarded
         - Deactivated and placarded INOPERATIVE
         - Any necessary maintenance must be accomplished by certified maintenance personal
           - a Maintenance must be recorded in accordance with FAR 43.9
     - iii. Required Equipment - 91.213(d)(2) – Follow these steps to decide if equipment is required: AI.III.B.K3
       - a. 14 CFR 91.205: Required Instruments and Equipment for Day and Night VFR Flight
         - Visual-Flight Rules (Day), The following instruments and equipment are required:
           - a Remember: TOMATO FFLAAMES
           - b **T**achometer for each engine

c **O**il pressure gauge for each engine
d **M**anifold pressure gauge for each altitude engine
e **A**irspeed Indicator
f **T**emperature gauge for each liquid-cooled engine
g **O**il temperature gauge for each air-cooled engine
h **F**uel gauge indicating the quantity of fuel in each tank
i **F**lotation gear (if operated for hire over water beyond power-off glide distance from shore)
j **L**anding gear position indicator
k **A**ltimeter
l **A**nti-Collision Lights (if certified after March 11, 1996)
m **M**agnetic compass
n **E**mergency Locator Transmitter
o **S**afety belts/Shoulder Harnesses

- Visual-Flight Rules (Night), The following instruments and equipment are required:

a All Instruments and equipment needed for VFR day flight are required, as well as:
b Remember: FLAPS
c **F**uses (if required)
d **L**anding Light (Electric)
e **A**nti-Collision Lights
f **P**osition Lights
g **S**ource of electricity for all installed electrical and radio equipment

b. Kinds of Operation Equipment List and Equipment List AI.III.B.K3c

- Kinds of Operation Equipment List

a Lists the manufacturer required equipment based on the type of flight (VFR Day, IFR, etc.) intended
b Located in Chapter 2 of the aircraft POH

- Equipment List

a Furnished with the aircraft is an equipment list that specifies all the required equipment approved for installation in the aircraft. The weight and arm of each item is included on the list, and all equipment installed when the aircraft left the factory is checked
b It is usually found in the weight and balance data

c. Type Certificate

- Definition

a The Type Certificate Data Sheet (TCDS) is a formal description of the aircraft, engine or propeller. It lists limitations and information required for type certification including airspeed limits, weight limits, thrust limitations, etc.

- Can be found on the FAA TCDS Website
- The type certificate will specify things like the type of engine, the propeller, the number of seats in the aircraft, etc.

a Things on the TC cannot be changed without a supplemental type certificate
1. You can't just decide to put a turbine engine in your Cessna 172

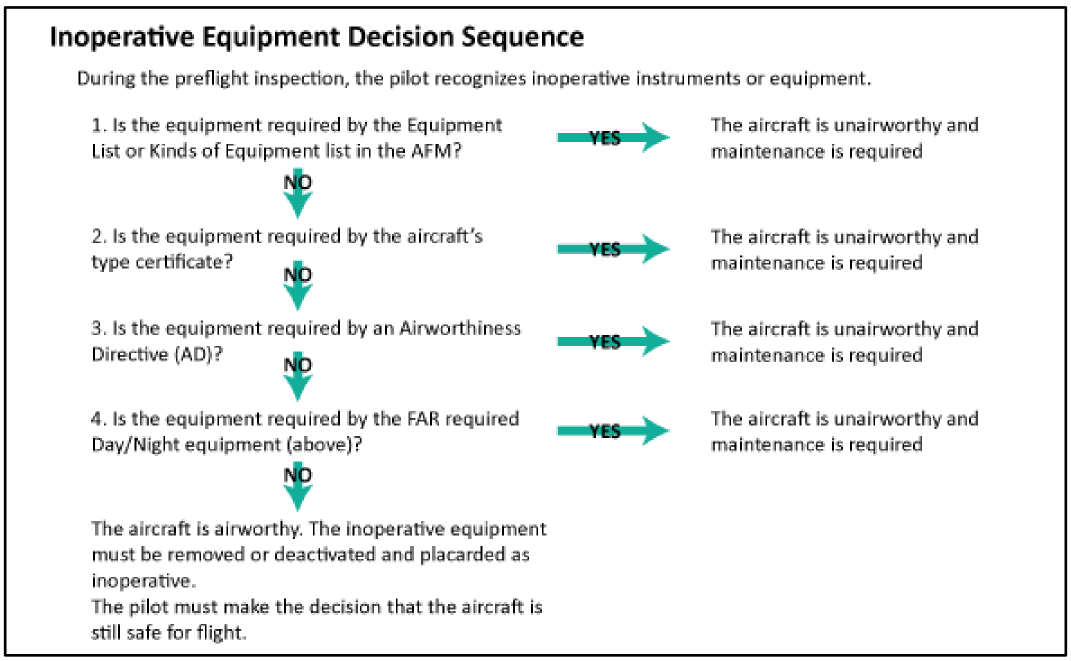
d. Airworthiness Directives (AD) AI.III.B.K1c

- Definition

a The means used to notify aircraft owners and other interested persons of unsafe conditions and to specify the conditions under which the product may continue to be operated
b Like a recall on a car

- ADs may be divided into two categories:

    a Those of an emergency nature requiring immediate compliance prior to further flight
    b Those of a less urgent nature requiring compliance within a specific period of time
- ADs are regulatory in nature and shall be complied with unless a specific exemption is granted
    a AD Database: FAA Dynamic Regulatory System
- It is the aircraft owner/operator's responsibility to ensure compliance with all pertinent ADs
    a If an AD is not complied with by the designated date/time period the aircraft is not airworthy and may not be flown
- Compliance Records
    a 14 CFR part 91.417 requires a record to be maintained showing the status of applicable ADs.
    b For ready reference, many aircraft owners have a chronological listing of the pertinent ADs in the back of their aircraft, engine, and propeller maintenance records
- Special Airworthiness Information Bulletin (SAIB) AI.III.B.K1c
    a Information tool that alerts, educates, and makes recommendations to the aviation community
    b Non-regulatory or mandatory info & guidance for safety issues that don't meet the criteria for an AD
        1. Keep in mind, ADs will not be issued for aircraft without a type certificate (Ex: amateur built)
            a. Although SAIBs are not regulatory, they may be very important
    c SAIB Overview: Order 8110.100
    d SAIB Database: FAA Dynamic Regulatory System



B. Airworthiness with a MEL AI.III.B.K3b
  i. An MEL is a precise listing of instruments, equipment, and procedures that allows an aircraft to be operated with inoperative equipment
    a. Basically, combines FAR 91.205, the Kinds of Equipment List, ADs and Type Certificate into one authoritative document
    b. Considered to be a supplemental type certificate and therefore becomes the authority to operate that aircraft in a condition other than originally type certificated
    c. A MEL must be requested from the FAA
    d. The FAA approved MEL includes only those items of equipment which may be inoperative and yet maintain an acceptable level of safety based on conditions and limitations

ii. Required Equipment
   a. If equipment or an instrument is found to be broken the pilot would refer directly to the MEL as to whether it is required for the type of flight
   b. Ex: If the position lights were discovered inoperative prior to a daytime flight, the pilot would make an entry in the maintenance record
      - The item is then either repaired or deferred in accordance with the MEL
         a If the MEL states that position lights are not necessary for a daytime flight then the aircraft is airworthy, the pilot would follow the instructions in the MEL regarding the position lights (e.g., pull the circuit breaker/do not use the lights, etc.) and the flight may continue
         b If it were a night flight and the MEL requires the position lights, then the aircraft is not airworthy, and the flight may not continue until repairs are made
   c. Should a component fail that is not listed in the MEL as deferrable (tachometer, flaps, stall warning device, etc.) then repairs are required to be performed prior to departure

C. Required Inspections AI.III.B.K1b
   i. 14 CFR part 91 places primary responsibility on the owner/operator for maintaining an aircraft in an airworthy condition
      a. After aircraft inspections have been made and defects repaired, the PIC is responsible for determining whether the aircraft is in condition for safe flight
   ii. Inspections: Remember AV1ATE
      a. **A**nnual Inspection
         - Any reciprocating-engine powered or single-engine-turbojet/turbo-propeller powered small aircraft (less than 12,500 pounds) flown for business or pleasure and not flown for compensation or hire is required to be inspected at least annually
         - Must be done by an airframe and powerplant mechanic (A&P) who holds an Inspection Authorization (IA)
         - An aircraft overdue for an annual inspection may be operated under a Special Flight Permit for the purpose of flying the aircraft to a location where the inspection can be performed
         - All applicable ADs that are due must be complied with
         - An annual inspection may be substituted for a required 100 hr. inspection
      b. **V**OR
         - The VOR must have been checked within the preceding 30 days. A record must be kept in a bound logbook (IFR Requirement)
      c. **1**00 Hour Inspection
         - All aircraft under 12,500 lbs. (except for turbo powered), used to carry passengers for hire or used for flight instruction for hire, must have received a 100-hour inspection
         - The inspection must be performed by an FAA certificated A&P mechanic, and appropriately rated FAA certificated repair station, or by the aircraft manufacturer
            a No IA necessary (like for the annual)
         - An annual inspection may be substituted for a required 100-hour inspection
         - The 100-hour limit may be exceeded by not more than 10 hours while enroute to reach a place where the inspection can be done
            a The excess time used must be included in computing the next 100 hours of time in service
      d. **A**ltimeter/Pitot Static Inspection
         - FAR 91.411 requires that the altimeter, encoding altimeter, and related system be tested and inspected in the preceding 24 months before operated in controlled airspace under instrument flight rules
         - FAR 91.411 - The pitot/static system must be checked within the preceding 24 calendar months. A

record must be kept in the aircraft logbook (IFR Requirement)

e. **T**ransponder Inspection
  - FAR 91.413 requires that before a transponder can be used under FAR 91.215(a), it shall be tested and inspected within the preceding 24 months

f. **E**LT Inspection
  - FAR 91.207(d) – If operations require an ELT, it must be inspected every 12 calendar months

D. Required Documents (show the student the location of each document and its expiration) AI.III.B.K1a
  i. Remember ARROW
    a. Airworthiness
    b. Registration
    c. Radio Operators License (if international)
    d. Operating Limitations (POH)
    e. Weight and Balance (specific to the aircraft tail number)
  ii. Standard & Special Airworthiness Certificates AI.III.B.K4
    a. Standard
      - White and issued for normal, utility, acrobatic, commuter or transport category aircraft
      - Issued by the FAA after an aircraft is found to meet Part 21 requirements and is safe for operation
      - Remains in effect as long as the aircraft receives required maintenance and is registered in the US
        a Safety relies in part on aircraft condition, which is verified by required inspections/maintenance
    b. Special
      - Pink and issued for Primary, Experimental, Restricted, Limited, Provisional and Light-Sport Aircraft
      - In general, aircraft with a special certificate, cannot be operated for hire, in some cases can't carry passengers, and may be restricted to operations only over sparsely populated areas or water
      - FAR 91.325 Primary Aircraft Operating Limitations
      - FAR 91.319 Experimental Aircraft Operating Limitations
      - FAR 91.313 Restricted Aircraft Operating Limitations
      - FAR 91.315 Limited Aircraft Operating Limitations
      - FAR 91.317 Provisional Aircraft Operating Limitations
      - FAR 91.327 Light Sport Aircraft with Special Airworthiness Certificate

3. Obtaining a Special Flight Permit AI.III.B.K1d

A. FAR 21.197: A Special Flight Permit is an authorization that may be issued for an aircraft that may not currently meet applicable airworthiness requirements, but is safe for a specific flight

B. Issued for the following reasons:
  i. Flying an aircraft to a base where repairs, alterations or maintenance are to be performed
  ii. Delivering or exporting an aircraft
  iii. Production flight testing new production aircraft
  iv. Evacuating aircraft from areas of impending danger
  v. Conducting customer demonstration flights
  vi. To allow the operation of an overweight aircraft for flight beyond its normal range where adequate landing facilities or fuel is not available.

C. Obtaining a Special Flight Permit
  i. If a special flight permit is needed, assistance and the necessary forms may be obtained from the local FSDO or Designated Airworthiness Representative (DAR)
  ii. FAR 21.199: an applicant for a special flight permit must submit a statement indicating:
    a. The purpose of the flight
    b. The proposed itinerary
    c. The crew required to operate the aircraft and its equipment, e.g., pilot, co-pilot, navigator, etc.

d. The ways, if any, in which the aircraft does not comply with the applicable airworthiness requirement
e. Any restriction the applicant considers necessary for safe operation of the aircraft
f. Any other information considered necessary by the FAA for the purpose of prescribing limitations

iii. FAA Special Flight Permit Regs & Policies

4. Appropriate Record Keeping (FAR 91.417) AI.III.B.K1a

A. The 100-Hour/Annual inspection as well as the inspections required for instruments and equipment necessary for legal VFR/IFR flight are in the aircraft and engine logbooks

B. Removing/Installing equipment not on the Equipment List
   i. The AMT must change the weight and balance record to indicate the new empty weight and empty weight center of gravity (EWCG), and the equipment list is revised to show which equipment is installed

C. Repairs and Alterations
   i. Major
      a. 14 CFR part 43, Appendix A: Major alterations shall be approved for return to service on FAA Form 337, Major Repairs and Major Alterations, by an appropriately rated certificated repair station, an FAA certificated A&P mechanic holding an Inspection Authorization, or a representative of the Administrator
   ii. Minor
      a. May be approved for return to service with a proper entry in the maintenance records by an FAA certificated A&P mechanic or an appropriately certificated repair station

5. Preventive Maintenance (AC 43-12) AI.III.B.K2

A. Who can Perform Preventive Maintenance?
   i. FAR 43.3(g): The holder of a pilot certificate issued under Part 61 may perform preventive maintenance
      a. Aircraft cannot be used under part 121, 129, or 135
      b. Sport Pilot: May perform preventive maintenance on an aircraft owned or operated by that pilot and issued a special airworthiness certificate in the light-sport category
   ii. Part 43 Appendix A paragraph (c)(30): The tasks must be performed by the holder of at least a private pilot certificate who is the registered owner (or co-owner) of the aircraft

B. Preventive Maintenance
   i. FAR 1.1: Simple or minor preservation operations and the replacement of small standard parts not involving complex assembly operations
   ii. Part 43 Appendix A paragraph (c) Provides an exhaustive list of authorized preventive maintenance
      a. If a task is not on the list, it's not preventive maintenance
      b. Due to differences in aircraft, preventive maintenance on one aircraft is not the same as another
         - To account for this, "provided it does not involve complex assembly operations" is included
         - Use good judgement when determining if a function classifies as preventive or not
      c. Ex: Replenishing hydraulic fluid, replacing batteries, replacing spark plugs, repairing broken circuits
   iii. FAR 43.13 Performance Rules - Requires that those performing the maintenance adhere to the following:
      a. Use acceptable methods, techniques, and practices. Normally set forth in the maintenance manual
      b. Use tools, equipment, and test apparatus necessary to ensure accordance with industry practices
      c. Use any special equipment, or the equivalent, recommended by the manufacturer
      d. The work and materials should be of a quality at least equal to its original condition
   iv. Conduct a self-analysis as to whether you can perform the work satisfactorily & safely
   v. FAR 43.9(a) Maintenance Record Entries - Any work done requires an entry in the logbook and must include:
      a. Description of the work done, Completion date, & Signature, certificate number, and kind of certificate

C. Return to Service
   i. FAR 43.7(f): A person holding at least a private pilot certificate may approve an aircraft for return to service after performing preventive maintenance under the provisions of 43.3(g)

D. Helpful Content
   i. AC 43-12 Preventive Maintenance

   ii. FAASafety.gov Maintenance Aspects of Owning Your Own Aircraft

6. Inoperative Equipment in Flight AI.III.A.K3a

- A. Maintenance deferrals are not used for inflight discrepancies
  - i. The manufacturer's POH procedures are to be used in those situations
- B. The POH takes precedence but combine risk assessment & mitigation techniques to assist in decision making
  - i. Consider how the inoperative equipment affects the flight
    - a. Can vary based on the type of flight (i.e., failure of lights during night flight vs day flight)
  - ii. PAVE checklist, and any other tools
  - iii. Apply personal minimums & requirements

Conclusion:
Brief review of each main point
The requirements and precautions mandated by the FAA are necessary to ensure the aircraft is in a safe condition for flight not only for legal reasons, but also for the safety of those onboard.

III.B. Airworthiness Requirements - FARS

References: 14 CFR Part 91

Objectives	The learner should exhibit knowledge of the elements regarding airworthiness requirements as necessary based on their respective ACS.
Elements	1. FAR 91.3 - Responsibility and Authority of the PIC 2. FAR 91.7 - Civil Aircraft Airworthiness 3. FAR 91.9 - Civil Aircraft Flight Manual, Marking, and Placard Requirements 4. FAR 91.203 - Civil Aircraft: Certifications Required 5. FAR 91.205 - Instrument and Equipment Requirements 6. FAR 91.213(d) - Inoperative Instruments and Equipment 7. FAR 91.400's - Maintenance, Preventative Maintenance, and Alterations (Subpart E) 8. FAR 91.207 - Emergency Locator Transmitters (ELT)
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner can explain, and when necessary locate, the elements and documents related to airworthiness requirements.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Just as you would never scuba dive without your regulator operating properly or sky dive without the rip cord functioning, you should never fly an airplane without essential equipment working properly. Unlike in a car, we do not have the option to pull over to the side of the road in the case of a problem.

Overview

Review Objectives and Elements/Key ideas

What

Airworthiness requirements are the basis for deciding whether an aircraft is worthy of safe flight. They are requirements that must be met to ensure an aircraft is safe and legal to fly.

Why:

For an airplane to be airworthy certain documents must be on board and current, certain inspections must be completed, and certain instruments must be functioning, otherwise the airplane is unfit for flight and therefore unairworthy or illegal to fly. An unairworthy aircraft cannot be flown. Determining airworthiness can be very complex. This lesson is designed to provide a basis to decide whether the airplane is airworthy.

How:

1. **FAR 91.3 - Responsibility and Authority of the PIC**
   - A. *The PIC is directly responsible for, and is the final authority as to, the operation of the plane*
   - B. In an in-flight emergency, the PIC may deviate from any rule of this part to the extent required
   - C. Each PIC who deviates from a rule under paragraph (b) of this section shall, upon the request of the Administrator, send a written report of that deviation to the Administrator
2. **FAR 91.7 - Civil Aircraft Airworthiness**
   - A. No person may operate a civil aircraft unless it is in an airworthy condition
     - i. Airworthiness: Read the Airworthiness Certificate (Best definition of airworthiness)
       - a. Authority and Basis for Issuance
         - States the aircraft must conform to the type certificate
           - a The aircraft cannot be changed from its type certificate; must be in the condition it left the factory in
             1. The only way the airplane can be changed is with a supplemental type certificate
       - b. Terms and Conditions
         - States that the aircraft must be maintained in accordance with the FARS
   - B. The PIC of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight and shall discontinue the flight when un-airworthy mechanical, electrical, or structural conditions occur
     - i. This is the only FAR which mentions a visual inspection, i.e., Condition for safe flight
3. **FAR 91.9 - Civil Aircraft Flight Manual, Marking, and Placard Requirements**
   - A. No person may operate a U.S.-registered civil aircraft:
     - i. For which an Airplane or Rotorcraft Flight Manual is required by FAR 21.5 of this chapter unless there is available in the aircraft a current, approved Airplane or Rotorcraft Flight Manual or the manual provided for in FAR 121.141(b); and
       - a. The Weight and Balance is included in the AFM, but is part of the type certificate and therefore required

ii. For which an Airplane or Rotorcraft Flight Manual is not required by FAR 21.5 of this chapter, unless there is available in the aircraft a current approved Airplane or Rotorcraft Flight Manual, approved manual material, markings, and placards, or any combination thereof

B. FAR 91.9 states that the AFM is required in the airplane for planes registered after 1979
   i. The AFM is not required for an airplane before 1979, unless the manufacturer submitted an AFM to the FAA, then it is required in the airplane
C. FAR 91.9 also states that without the AFM, all placards, markings, etc. must be in the aircraft

4. **FAR 91.203 - Civil Aircraft: Certifications Required**
   A. Except as provided in FAR 91.715, no person may operate a civil aircraft unless it has within it the following:
      i. An appropriate and current airworthiness certificate…
         a. It must be displayed at the cabin or flight deck entrance so that it is legible to passengers or crew
      ii. An effective U.S. registration certificate issued to its owner…
5. **FAR 91.205 - Instrument and Equipment Requirements**
   A. The bare minimum instruments and equipment required for day/night VFR flight and IFR flight
      i. VFR – TOMATOFFLAAMES (day) and FLAPS (night)
      ii. IFR - GRABCARD
6. **FAR 91.213(d) - Inoperative Instruments and Equipment**
   A. MEL
      i. An FAA approved listing of instruments/equipment that may be inoperable and remain airworthy
   B. Without an MEL – FAR 91.213(d)
      i. Follow the flow provided in AC 91-67 (AC 91-67 has been cancelled)
         a. Is it required by the aircraft's equipment list or the kinds of equipment list?
         b. Is it required by the VFR type certificate requirements prescribed in the airworthiness certification requirements?
         c. Is it required by an AD?
         d. Is it required by FAR 91.205, 91.207, etc.?
         e. If no, the inoperative equipment must be removed or deactivated and placarded as inoperative
            - FAR 91.405 - Inoperative equipment must be repaired, replaced, removed at the next required inspection
         f. Finally, the PIC decides whether the equipment creates a hazard for the anticipated flight
7. **FAR 91.400's - Maintenance, Preventative Maintenance, and Alterations (Subpart E)**
   A. FAR 91.401 - Applicability
      i. Rules governing maintenance, preventative maintenance, alterations of US registered civil aircraft
   B. FAR 91.405 - Maintenance Required
      i. Each owner or operator of an aircraft:
         a. Shall have that aircraft inspected as prescribed in subpart E of this part and shall between required inspections, have discrepancies repaired as prescribed in part 43 of this chapter
         b. Shall ensure that maintenance personnel make appropriate entries in the aircraft maintenance records indicating the aircraft has been approved for return to service
         c. Shall have any inoperative instrument/equipment, permitted to be inoperative by FAR 91.213(d)(2) of this part, repaired, replaced, removed, or inspected at the next required inspection
         d. When listed discrepancies include inoperative instruments or equipment, shall ensure that a placard has been installed as required by FAR 43.11 of this chapter.
   C. FAR 91.409 - Inspections
      i. Annual Inspection requirement
      ii. 100-hour inspection requirement, if for rent or for hire
   D. FAR 91.411 - Altimeter system and Altitude Reporting Equipment Tests and Inspections
      i. Static Pressure System and Altimeter tests required for IFR flight

        a. Required every 24 calendar months
    E. FAR 91.413 - ATC Transponder Tests and Inspections
        i. Transponder tests and inspections required
            a. Required every 24 calendar months

8. FAR 91.207 - Emergency Locator Transmitters (ELT)

A. Inspection requirements
    i. Every 12 calendar months
B. The batteries must be replaced (or recharged)
    i. When the transmitter has been in use more than 1 cumulative hour
    ii. When 50% of their useful life has expired

Conclusion:

Through the FARS mentioned here, we find that the PIC is the final authority as to the safety of the flight. Airworthiness requires conforming to the type certificate, as well as the required maintenance and inspections. To be airworthy, the documents required onboard are the airworthiness certificate, the registration, operating limitations (AFM), as well as the weight and balance (part of the type certificate). We have found the required equipment as well as the process for determining whether the airplane is airworthy in the case of inoperative equipment. Finally, the FARs provided the necessary inspections needed to maintain airworthiness.

III.C. Weather Information

References: 14 CFR Part 91, Aviation Weather Handbook (FAA-H-8083-28), Aviation Weather Handbook (FAA-H-8083-28), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM

Objectives — The learner should develop knowledge of the elements related to weather information with the ability to interpret several weather sources and make an educated Go/No Go decision.

Key Elements
1. Information Sources
2. FSS - 122.2
3. Go/No Go Decision

Elements
1. Atmospheric Composition & Stability
2. Wind
3. Temperature
4. Moisture & Precipitation
5. Weather System Formation
6. Clouds
7. Turbulence
8. Thunderstorms
9. Frost & Icing
10. Fog & Mist
11. Obstructions to Visibility
12. Importance of a Thorough Weather Briefing
13. Weather Information Sources
14. Weather Reports and Charts
    a. METAR, TAF, and GFA
    b. Model Output Statistics
    c. Surface Analysis Chart
    d. Ceiling & Visibility Chart
    e. Wind & Temperature Aloft Forecast
    f. Convective Outlook
15. In-Flight Weather Advisories
16. Go/No Go Decision

Schedule
- Discuss Objectives
- Review material
- Development
- Conclusion

Equipment
- White board and markers
- References

IP's Actions
- Discuss lesson objectives
- Present Lecture
- Ask and Answer Questions
- Assign homework

SP's Actions
- Participate in discussion
- Take notes
- Ask and respond to questions

Completion Standards — The learner can effectively interpret the necessary weather information and make a competent Go/No Go decision based on the information.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Instead of getting ourselves stuck airborne in a thunderstorm or some other extreme weather, we should have a good understanding of weather information to know when to and not to fly.

Overview

Review Objectives and Elements/Key ideas

What

First, a discussion of weather – how it forms, interacts, and its relation to flying. And second, through a complex system of weather services, government agencies, and independent weather observers, pilots are given vast information regarding weather patterns, trends, and characteristics in the form of up-to-date weather reports and forecasts

Why

This knowledge, and the reports and forecasts enable pilots to make informed decisions regarding weather and flight safety.

How:

1. **Atmospheric Composition and Stability** AI.III.C.K3a
    - A. Composition
        - i. 4 gases make up 99.998% of the atmosphere - Nitrogen, Oxygen, Argon and Carbon Dioxide
    - B. Vertical Structure
        - i. The Earth's atmosphere is divided into 5 concentric layers based on the vertical profile of average air temperature changes, chemical composition, movement, and density
            - a. Troposphere
                - Begins at the Earth's surface and extends up to about 36,000' high. As the gases decrease with height, the air becomes thinner, and temperature also decreases with height. Almost all weather occurs in this region
                - The vertical height of the troposphere varies due to temperature variations. The transition layer between the troposphere and they layer above is called the tropopause
            - b. Stratosphere
                - Extends from the tropopause up to 31 miles above the Earth's surface. This layer holds 19% of the atmosphere's gases, but very little water. Temperature increases with height due to the absorption of UV radiation
                - Commercial aircraft often cruise in the lower stratosphere to avoid atmospheric turbulence and convection in the tropopause
                    - a Disadvantages of flying in this layer include increased fuel consumption due to warmer temperatures, increased radiation, and increased ozone concentrations
            - c. Mesosphere
                - Extends from the Stratopause to about 53 miles above the Earth. Gases continue to thin so warming becomes less pronounced leading to a decrease in temperature with height
            - d. Thermosphere
                - Extends from the Mesopause to 430 miles above the Earth. This layer is known as the upper

atmosphere. The gases become increasingly thin compared to the mesosphere and only high energy UV and X-ray radiation from the sun is absorbed - temperature increases with height and can reach 2,000 degrees Celsius near the top of the layer

a Surprisingly, this layer would still feel very cold to us due to the extremely thin air

e. Exosphere

- The outermost layer of the atmosphere - extends from the thermopause to 6,200 miles. In this layer, atoms and molecules escape into space, and satellites orbit the Earth

C. Standard Atmosphere (59°F/15°C, 29.92” Hg)

i. Continuous fluctuations of atmospheric properties create problems for engineers and meteorologists who require a fixed standard for reference. To solve this problem, they defined a standard atmosphere, which represents an average of conditions throughout the atmosphere for all latitudes, seasons, and altitudes. Standard atmosphere is a hypothetical vertical distribution of atmospheric temperature, pressure, and density that, by international agreement, is taken to be representative of the atmosphere

2. Wind AI.III.C.K3b

A. Air in motion relative to the surface. Wind causes the formation/dissipation/redistribution of weather

B. Wind also affects aircraft in all phases of flight

i. Adverse wind is responsible for many weather-related accidents

a. Crosswinds, gusts, tailwind, variable wind, sudden wind shift, wind shear, mountain wind hazards

C. Forces that Affect the Wind – Pressure Gradient Force, Coriolis Force, Friction

i. Pressure Gradient Force (PGF)

a. Wind flows from areas of high to low pressure. These different pressures create the PGF

b. Whenever a pressure difference develops over an area, the PGF makes the wind blow in an attempt to equalize the differences

- This force is identified by height contour gradients on constant pressure charts and by isobar gradient on surface charts

c. PGF is directed from higher pressure to lower pressure and is perpendicular to contours/isobars

d. Wind speed is proportional to PGF which is proportional to the contour/isobar gradient

- Closely spaced contours/isobars indicate strong winds; widely spaced indicates light winds

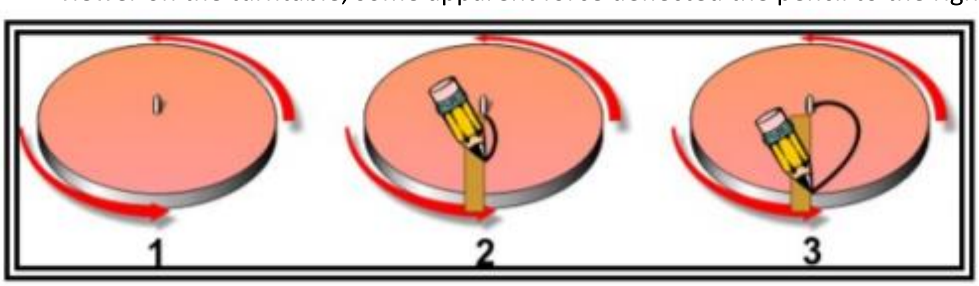
e. Wind would simply flow from high to low pressure if the PGF was the only force acting on it, but because of the Earth’s rotation, the Coriolis force affects the direction of wind flow as well

ii. Coriolis Force

a. Air is deflected to the right in the northern hemisphere and left in the southern

b. A moving mass travels in a straight line until acted on by some outside force. However, if one views the moving mass from a rotating platform, the path of the moving mass relative to his platform appears to be deflected or curved.

- To illustrate, consider a turntable. If one used a pencil and a ruler to draw a straight line from the center to the outer edge of the turntable, the pencil will have traveled in a straight line. However, stopping the turntable it is evident that the line spirals outward from the center. To a viewer on the turntable, some apparent force deflected the pencil to the right.



c. Deflects air to the right in the Northern Hemisphere & left in the Southern Hemisphere

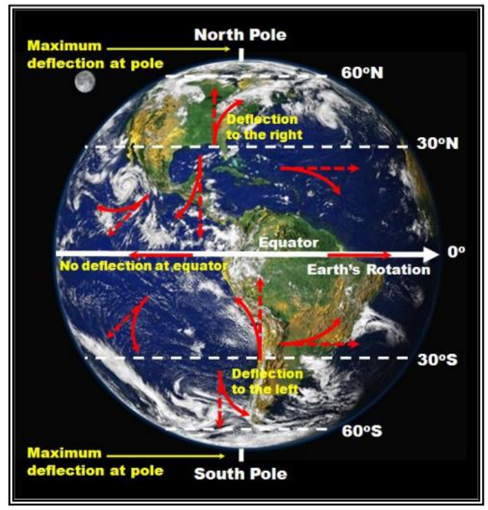
- At a right angle to wind direction
- Directly proportional to wind speed
  - a If wind speed doubles, Coriolis doubles
- Coriolis varies with latitude
  - a Zero at the equator & maximum at each pole

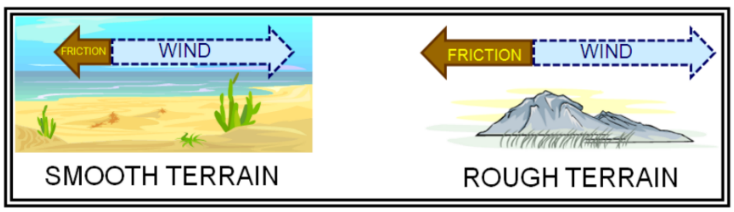
iii. Friction

a. Friction between the wind and the terrain surface slows the wind. The rougher the terrain, the greater the frictional effect, and the stronger the wind speed, the greater the friction

b. The frictional drag of the ground normally decreases with height and becomes insignificant above the lowest few thousand feet or so

c. Above the friction layer, only the PGF and Coriolis force affect the horizontal motion of the air





D. Adverse Winds

i. Wind Shear

a. What is it?

- A sudden, drastic change in wind speed and/or direction over a very small area
- Can occur at any altitude
  - a Low-level wind shear is especially hazardous due to the proximity to the ground
  - b Low-level wind shear is commonly associated with passing frontal systems, thunderstorms, temperature inversions, and strong upper-level winds (greater than 25 knots)

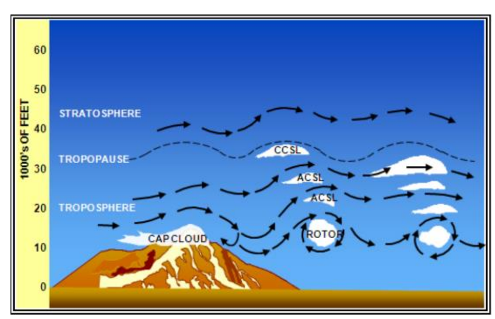
b. Why is it dangerous?

- Can cause violent updrafts/downdrafts, and abrupt changes to horizontal movement
- It can rapidly change performance and disrupt the normal flight attitude, for example:
  - a A tailwind can quickly change to a headwind, increasing airspeed and performance
  - b A headwind can quickly change to a tailwind, decreasing airspeed and performance
- Although reported, it often remains undetected
  - a Be alert for wind shear, especially when flying around thunderstorms & frontal systems

ii. Mountain Waves

a. What is it?

- The atmosphere is a fluid in motion
  - a Just as a stream develops waves & eddies as it passes obstructions, so does the atmosphere
- When the atmosphere encounters a mountainous barrier, a few responses are possible
  - a If the wind is weak or exceptionally dense, the mountain may act as a dam, stopping the air
  - b More often, strong winds flow over/around



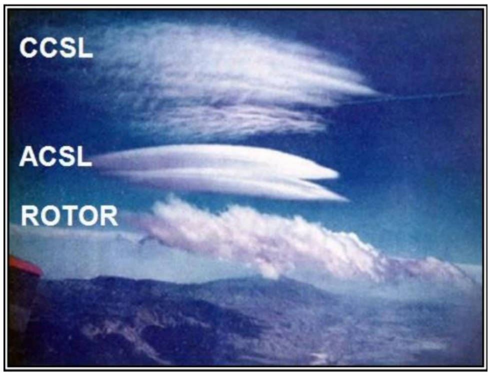
mountains

1. If the atmosphere is unstable, the vertical movement can create thunderstorms

c If the wind is sufficiently strong and the atmosphere is stable, a wave will develop

b. Hazards
   - Generally, produce strong down drafts and/or turbulence on the immediate leeward side of the mountain

c. Visual Indicators
   - Sharp-edged, lens-shaped lenticular clouds
   - With sufficient moisture in the upstream flow, cloud formations can include:
     a Cap clouds, Cirrocumulus Standing Lenticular (CCSL), Altocumulus Standing Lenticular (ACSL), and rotor clouds
     b These clouds provide evidence of mountain waves, but may be absent if the air is too dry



d. Types of Waves
   - For significantly more details, there are several waves discussed in Ch. 16 of the Aviation Weather Handbook
     a Gravity Waves, Kelvin-Helmholtz (K-H) Waves, Vertically Propagating Mountain Waves, Trapped Lee Waves, and more

3. Temperature AI.III.C.K3c

A. Temperature

i. Temperature represents the average kinetic energy of the molecules in matter. Higher indicates a higher average kinetic energy and vice versa - temp is an indicator of the internal energy of air

ii. Heat Transfer

a. Heat transfer is energy transfer as a consequence of temperature difference
   - When an object/fluid is at a different temperature than its surroundings heat transfer occurs such that the object/fluid and the surroundings reach thermal equilibrium (balance)

b. The heat source for the planet is the sun. Energy from the sun is transferred to the Earth's surface. There are 3 ways heat is transferred into and through our atmosphere:
   - Radiation
     a Ex. Being near a fireplace - the side of your body nearest the fire warms
     b The sun radiates heat to the Earth
   - Conduction
     a Transfer of energy by molecular activity from one substance to another in contact
       1. Heat always flows from the warmer substance to the colder substance
       2. Warmer substance cools/loses heat while the cooler substance warms/gains energy
   - Convection
     a The transport of heat within a fluid, such as air or water, via motions of the fluid itself
       1. Water boiling in a pot is an example of convection
     b Because air is a poor thermal conductor, convection plays a vital role in the Earth's atmospheric heat transfer process

B. Heat Exchange

i. Thermal Response

a. Water is much more resistant to temperature changes than land
   - It warms and cools more slowly than land and helps moderate nearby air temperature
   - This is why coastal cities experience smaller seasonal temperature variations than inland

- ii. Temperature Variations with Altitude
  - a. Temperature generally decreased at an average of 2 degrees Celsius per 1,000'
    - But in the troposphere, temperature can remain constant or increase with altitude changes
      - a Isothermal Layer: An atmospheric layer where temperature remains constant with height
      - b Temperature Inversion: A layer in which the temperature increases with altitude
        1. If the base is at the surface, it is a surface-based inversion
           - a. Typically occurs over land on clear nights with light wind.
           - b. Ground radiates faster than the overlying air
           - c. Air in contact with the ground cools, while air a few hundred feet stays the same
        2. If it is not at the surface, it is an inversion aloft
           - a. Ex: a current of warm air aloft overrunning cold air near the surface
        3. Principle characteristic of an inversion layer is its marked stability – very little turbulence

4. Moisture & Precipitation AI.III.C.K3d

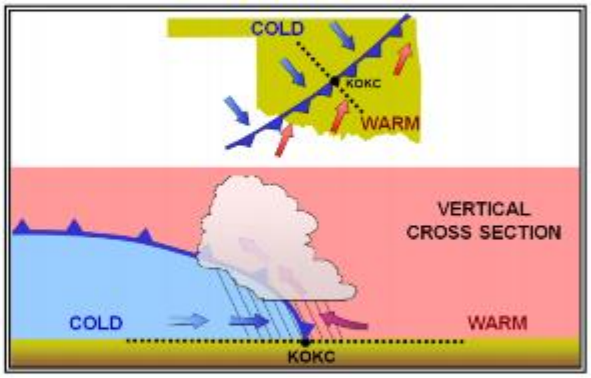
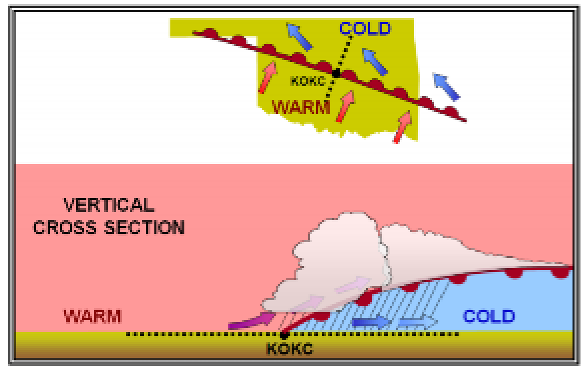
- A. Necessary Ingredients
  - i. Water Vapor
  - ii. Sufficient Lifting - condenses the water vapor into clouds
  - iii. Growth Process - allows cold droplets to grow large and heavy enough to fall as precipitation
    - a. All clouds contain water, but only some produce precipitation. This is because cloud droplets and/or ice crystals are too small and light to fall to the ground as precipitation.
    - b. Two growth processes allow cloud droplets to grow large enough to fall as precipitation
      - Collision-Coalescence (warm rain process)
        - a Collisions between droplets of varying size and fall speeds coalesce to form larger drops
        - b Drops become too large to be suspended in the air and fall to the ground as rain
        - c Primary growth process in warm, tropical air masses with a very high freezing level
      - Ice Crystal Process
        - a Occurs in colder clouds with both ice crystals and water droplets
        - b Water vapor deposits directly on to ice crystals which in time become heavy enough to fall
        - c Thought to be the primary growth process in mid and high latitudes
- B. Precipitation Types
  - i. The vertical distribution of temperature often determines the precipitation at the surface
  - ii. Rain
    - a. Deep layer of above freezing air based at the surface
  - iii. Snow
    - a. Occurs when the temperature is below freezing throughout the entire depth of the atmosphere
  - iv. Ice Pellets
    - a. Require a shallow, above freezing layer aloft, and a deep, below freezing layer at the surface
      - As snow falls into the shallow, warm layer, the snowflakes partially melt. As the precipitation enters the below freezing surface air it freezes into ice pellets
  - v. Freezing Rain
    - a. Occurs with a deep, above freezing layer aloft and a shallow, below freezing layer at the surface
      - Rain falls into the below freezing air, but since the depth is shallow it doesn't have time to freeze into ice pellets. The drops freeze on contact with the ground or exposed objects

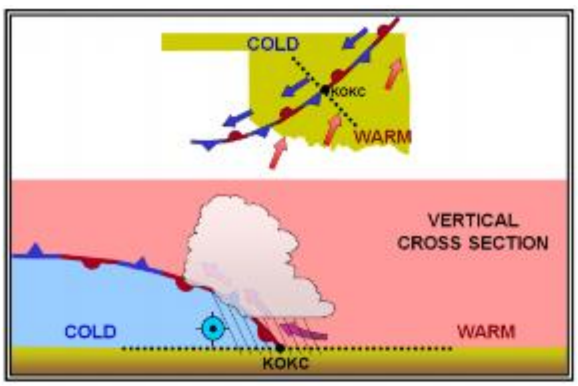
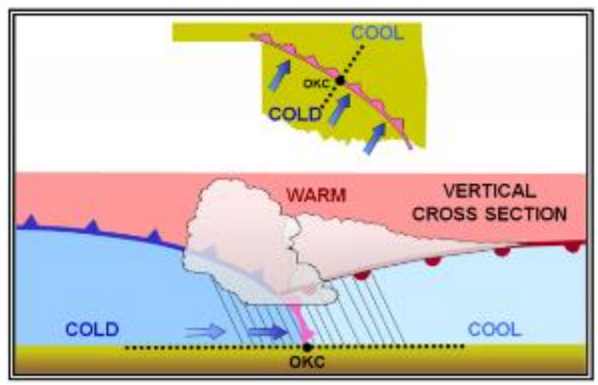
5. Weather System Formation AI.III.C.K3e

- A. Air Masses
  - i. A large body of air with generally uniform temperature and humidity.
  - ii. Area from which an air mass originates is called a source region
    - a. Range from extensive snow-covered polar areas to deserts to tropical oceans
    - b. The longer an air mass stays over its source region, the more likely it will acquire its properties

iii. Classified according to temperature and moisture properties of the source region
    a. Temperature Properties
        - Arctic: Extremely deep cold air mass; develops mostly in winter over arctic ice/snow
        - Polar: A relatively shallow cool to cold air mass which develops over high latitudes
        - Tropical: A warm to hot air mass which develops over low latitudes
    b. Moisture Properties
        - Continental: A dry air mass which develops over land
        - Maritime: A moist air mass which develops over water
    c. Types of Air Masses (Temperature + Moisture Properties)
        - Continental Arctic: Cold, dry
        - Continental Polar: Cold, dry
        - Continental Tropical: Hot, dry
        - Maritime Polar: Cool, moist
        - Maritime Tropical: Warm, moist
        - Maritime Arctic seldom, if ever, forms
iv. Air Mass Modification
    a. As an air mass moves around the Earth, it can acquire different attributes
        - Ex: In the winter, an arctic air mass (cold and dry) can move over the ocean, picking up warmth and moisture from the warmer ocean and become a maritime polar air mass

B. Fronts
i. Air masses can control weather for a relatively long-time period ranging from days to months. Most weather occurs along the periphery of these air masses at boundaries called fronts
ii. A front is a boundary or transition zone between two air masses
    a. Fronts are classified by which type of air mass (cold or warm) is replacing the other
iii. Fronts are usually detectable at the surface in several ways:
    a. Significant temperature gradients
    b. Converging winds
    c. Pressure typically decreases as a front approaches and increases after it passes
iv. Fronts do not only exist at the surface, but also have a vertical structure described here:

Cold Front	Warm Front
	
Cold fronts have a steep slope, and the warm air is forced up abruptly. If the warm rising air is unstable, this often leads to a narrow band of showers and thunderstorms along, or just ahead of, the front.	Warm fronts have a gentle slope, so the warm air rising along the frontal surface is gradual. This favors the development of widespread layered or stratiform cloudiness and precipitation along, and ahead of, the front if the warm rising air is stable.

Stationary Front	Occluded Front
	
Stationary frontal slopes can vary, but clouds and precipitation would still form in the warm rising air along the front.	Cold fronts typically move faster than warm fronts, so in time they catch up to warm fronts. As the two fronts merge, an occluded front forms. The cold air undercuts the retreating cooler air mass associated with the warm front, further lifting the already rising warm air Clouds and precipitation can occur in the areas of frontal lift along, ahead of, and behind the surface position of an occluded front

6. Clouds

AI.III.C.K3f

A. Vertical Motion & Cloud Formation

i. Air cools as it rises

a. As pressure decreases the air parcel expands, which requires energy, cooling the air

- Adiabatic process: No heat transfer into, or out of, the parcel of air

b. Temp decreases 3° C per 1,000' (dry adiabatic lapse rate), dewpoint decreases 0.5° C per 1,000'

- Temperature-dewpoint spread decreases while relative humidity increases

c. Reaches a point where temp and dewpoint are equal and the particle becomes saturated

ii. Lifted Condensation Level (LCL): Level at which a parcel of air becomes saturated

a. Temp-dewpoint spread is zero and relative humidity is 100%

iii. Lifting above the LCL results in condensation, cloud formation and heat release

a. Heat added during condensation offsets some cooling due to expansion

- Moist lapse rate varies between 1.2° C per 1,000' for very warm particles & 3° for cold particles
  - a This is where the average 2° C per 1,000' lapse rate is derived

iv. As the air parcel expands and cools, water vapor content decreases

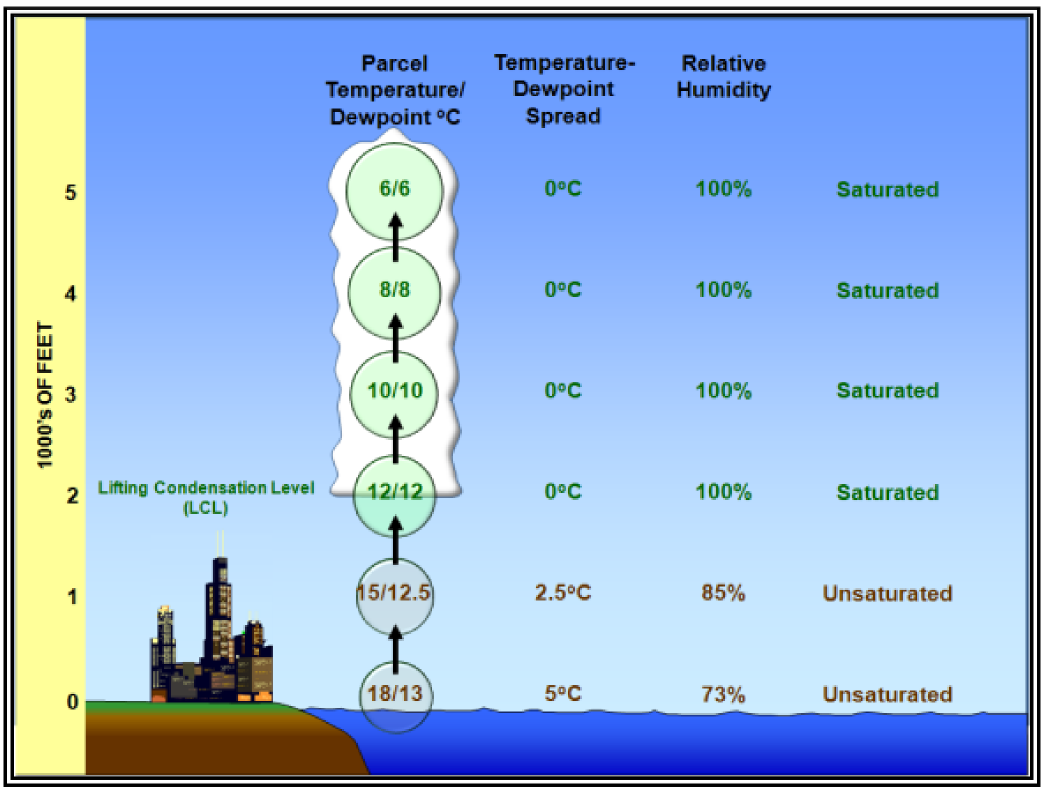
a. Some water vapor is condensed to droplets or deposited into ice crystals to form a cloud

b. Process is triggered by microscopic cloud condensation (and ice) nuclei

- Dust, clay, soot, sulfate, and sea salt particles

c. The cloud grows vertically as the parcel continues to rise

v. Opposite occurs as a particle descends



B. Sources of Vertical Motion

i. Orographic Effects

a. Wind blowing across mountains and valleys causing the air to ascend/descend

ii. Frictional Effects

a. In the Northern Hemisphere, surface wind spirals clockwise and outward from high pressure and

counterclockwise and inward into low pressure due to frictional force
  - b. Winds diverge away from high pressure causing air to sink, compress, & war, dissipating clouds
  - c. Winds converge into low pressure causing air to rise, expand, & cool, favoring clouds & precipitation
- iii. Frontal Lift
  - a. Cold, denser air wedges under warm, less dense air, forcing it upward
  - b. Warm air rides up and over cold air in a process called overrunning
- iv. Buoyancy
  - a. Air near the ground can warm at different rates
    - Ex. Newly plowed field will warm faster than an adjacent lake
  - b. Temperature differences result in different air densities, allowing warm air to rise and cold to sink

C. Clouds
- i. Cloud Forms
  - a. Cirri-form
    - High level clouds above 20,000’ usually composed of ice crystals
    - Typically, thin and white
    - Occur in fair weather and point in the direction of air movement

Cirri-form

  - b. Nimbo-form
    - Nimbus comes from the Latin word meaning rain
    - Typically, between 7,000 and 15,000’ with steady precipitation
    - As clouds thicken and precipitation begins to fall, the bases tend to lower toward the ground

Nimbo-form

  - c. Cumuli-form
    - White, fluffy cotton balls (show the vertical motion in the atmosphere)
    - Flat cloud base indicates the level of condensation/cloud formation
    - Height depends on humidity of rising air –more humid = lower cloud base
    - Tops can reach > 60,000’

Cumuli-form

  - d. Strati-form
    - Stratus is Latin for layer or blanket
    - Featureless low layer that can cover the entire sky, like a blanket
    - Usually only a few hundred feet AGL – over hills/mountains they can reach the ground and are fog
    - As fog lifts due to daytime heating, it can form a layer of low stratus clouds

Strati-form

- ii. Cloud Levels
  - a. High, Middle, and Low
  - b. In each level, the clouds may be divided by type

Level	Polar Regions	Temperate Regions	Tropical Regions
High Clouds	10,000–25,000 ft (3–8 km)	16,500–40,000 ft (5–13 km)	20,000–60,000 ft (6–18 km)
Middle Clouds	6,500–13,000 ft (2–4 km)	6,500–23,000 ft (2–7 km)	6,500–25,000 ft (2–8 km)
Low Clouds	Surface–6,500 ft (0–2 km)	Surface–6,500 ft (0–2 km)	Surface–6,500 ft (0–2 km)

- iii. Cloud Types

a. High Clouds

Cirrus	Cirrocumulus	Cirrostratus
		
Detached cirriform elements in the form of white, delicate filaments of white patches, or narrow bands. Many of the ice crystal particles are sufficiently large to acquire appreciable speed of fall; therefore, the clouds often trail downward in well-defined wisps called mares' tails. Cirrus clouds in themselves have little effect on aircraft and contain no significant icing or turbulence.	A cirriform type appearing as a thin, white patch, sheet, or layer of could without shading, and is composed of very small elements in the form of grains, ripples, etc. May be composed of highly super cooled water droplets, as well as small ice crystals, or a mix of both. Pilots can expect some turbulence and icing	Appears as a whiteish veil, usually fibrous but sometimes smooth, that may totally cover the sky, and that often produces halo phenomena. May be so thin and transparent as to render it nearly indiscernible – the existence of a halo around the sun or moon may be the only revealing feature. Composed primarily of ice crystals and contain little, if any, icing and no turbulence.

b. Middle Clouds

Altocumulus	Altocumulus Lenticularis	Altostratus
		
White and/or grey in color, that occurs as a layer or patch with a wave aspect, the elements of which appear as laminae, rounded masses, rolls, etc. Small liquid water droplets compose the major part of the composition of altocumulus. This results in sharp outline and small internal visibility. At very low temperatures ice crystals may form. Pilots can expect some turbulence and small amounts of icing	Commonly known as Altocumulus Standing Lenticular, they are an orographic cloud. They often form in patches in the shape of almonds or wave clouds. These formations are caused by wave motions in the atmosphere, and are frequently seen in mountainous or hilly areas. The cloud as a whole is usually stationary or slow moving. The clouds do not necessarily give an indication of the intensity of turbulence or strength of updrafts and downdrafts.	A cloud type in the form of a gray or bluish sheet or layer of striated, fibrous, or uniform appearance. It very often totally covers the sky. Portions of the layer are thin and it can have irregularly shaped and spaced gaps and rifts. Layers in the cloud: • Upper - mostly ice crystals • Middle - mixed ice crystals and/or snowflakes and super cooled water droplets • Lower- mostly super cooled or ordinary water droplets Pilots can expect little to no turbulence, but light to moderate icing in the super cooled water.
Nimbostratus		
	A gray cloud layer, often dark, rendered diffuse by more or less continuously falling rain, snow, ice pellets, etc. which in most cases reaches the ground. Not accompanied by lightning, thunder, or hail. Composed of suspended water droplets, sometimes super cooled, and failing raindrops/snow crystals or snowflakes. Nimbostratus has no well-defined base. A false base may occur where snow melts into rain. It produces very little turbulence but can pose a serious icing problem if temperatures are near or below freezing.	

c. Low Clouds

Cumulus and Towering Cumulus	Stratocumulus	Stratus
		
Individual, detached elements that are generally dense. They develop vertically, appearing as rising mounds, the upper parts of which often resemble cauliflower. Sunlit parts are white, while their bases are darker and nearly horizontal. The first stage of a thunderstorm. If rain occurs, it is usually showery. For cumulus with little vertical development, pilots can expect some turbulence and no significant icing. For towering cumulus, expect very strong turbulence and clear icing above the freezing level.	Predominantly stratiform, in the form of a gray/whiteish layer or patch, which nearly always has dark parts and is non-fibrous. Rounded/roll-shaped, and usually are arranged in orderly groups. Composed of small water droplets, and sometimes larger droplets, soft hail, even snowflakes. The highest liquid content is in the tops (icing potential). Virga may form under the cloud. Precipitation rarely occurs. Pilots can expect some turbulence and possible icing. Ceiling and visibility are usually better with low stratus.	A cloud type in the form of a gray layer with a fairly uniform base. The composition is quite uniform, usually of fairly widely dispersed water droplets, and at lower temperatures, ice crystals (rare). Doesn't often create precipitation, but when it does, it is in the form of minute particles, such as drizzle, ice crystals, or snow grains. Stratus produces little or no turbulence, but temperatures near or below freezing can create hazardous icing conditions.
Cumulonimbus		
	Exceptionally dense and vertically developed cloud, occurring either as isolated clouds or as a line or wall of clouds. The upper part often is in the form of an anvil or vast plume. Under the base (often dark) there frequently exists virga, precipitation, and low, ragged clouds. Composed of water droplets/ice crystals. Also contains large water drops, snowflakes, snow pellets, even hail. The water may be super cooled. Precipitation is often heavy/showery. Lightning is common. Cumulonimbus contains nearly the entire spectrum of flying hazards, including extreme turbulence.	

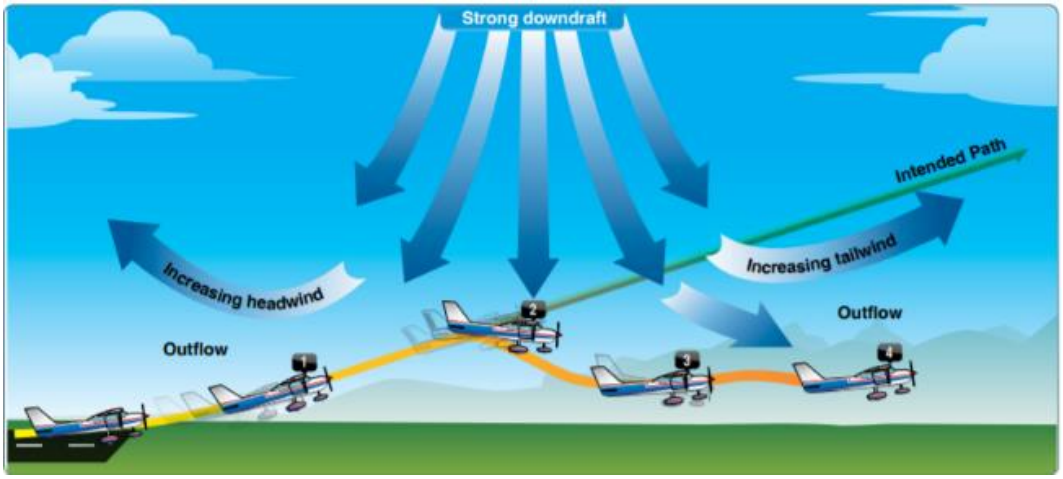
7. **Turbulence** AI.III.C.K3g
   A. Turbulence is caused by convective currents, obstructions in the wind flow, and wind shear
   B. Convective Turbulence
      i. Turbulent vertical motions that result from convective currents and the subsequent rising and sinking of air. For every rising current, there is a compensating downward current
      ii. Billowy cumuliform clouds, usually seen overland during sunny afternoons, are signposts in the sky indicating convective turbulence
      iii. A pilot can expect turbulence beneath or in the clouds
         a. When air is too dry for cumuliform clouds, convective currents can still be active. A pilot has little or no indication of their presence.
   C. Mechanical Turbulence
      i. Caused by obstructions to the wind flow, such as trees, buildings, mountains, and so on. Obstructions to the wind flow disrupt smooth wind into a complex snarl of eddies
      ii. Mountain Waves (also discussed in Winds)
         a. When stable air flow passes over a mountain or ridge, developing waves above and downwind of mountains. Can extend 600 miles or more downwind and vertically up to 200,000' and higher
         b. Can produce violent down drafts on the immediate leeward side of the mountain barrier and if the air is moist enough, cap clouds, cirrocumulus standing lenticular, altocumulus standing lenticular and rotor clouds are a clear sign of mountain waves.
   D. Wind Shear Turbulence (also discussed in Winds)
      i. Wind shear is the rate of change in wind direction and/or speed per unit distance and may be associated with either a wind shift or a wind speed gradient at any level in the atmosphere
      ii. Temperature Inversion
         a. A layer of the atmosphere in which temperature increases with altitude. Strong wind shears often occur across temperature inversion layers, which can generate turbulence
      iii. Clear Air Turbulence
         a. A higher altitude turbulence phenomenon occurring in cloud-free regions associated with wind shear, particularly between the core of a jet stream and the surrounding air
8. **Thunderstorms** AI.III.C.K3h
   A. Ingredients
      i. Sufficient Water Vapor
         a. Commonly measured using dew point, must be present to produce unstable air
      ii. Unstable Air
         a. Virtually all showers/thunderstorms form in an air mass that is classified as conditionally unstable
      iii. Lifting Mechanism
         a. A conditionally unstable air mass requires a lifting mechanism strong enough to release the instability. These include:
            - Converging winds around surface lows and troughs, fronts, upslope flow, drylines, outflow boundaries generated by prior storms, and local winds, such as sea breeze, lake breeze, land breeze, and valley breeze circulations
   B. Life Cycle
      i. Towering Cumulus
         a. A strong convective updraft. The updraft is a bubble of warm, rising air concentrated near the top of the cloud which leaves a cloudy trail in its wake
      ii. Mature
         a. The cell transitions to the mature stage when precipitation reaches the surface. Precipitation descends through the cloud and drags adjacent air downward, creating a strong downdraft alongside the updraft. The downdraft spreads out along the surface as a mass of cool, gusty air

iii. Dissipating
   a. The dissipating stage is marked by a strong downdraft embedded within the area of precipitation. Subsiding air replaces the updraft throughout the cloud, effectively cutting off the supply of moisture provided by the updraft. Precipitation tapers off and ends. The convective cloud gradually vaporizes from below

C. Types of Thunderstorms
   i. Single Cell
      a. Consists of only one cell. Easily circumnavigated, except at night or when embedded in other clouds. Single cell thunderstorms are rare; almost all are multicell
   ii. Multicell
      a. Consists of a cluster of cells at various stages of their life cycle. As the first cell matures, it is carried downwind, and a new cell forms upwind to take its place. New cells will continue to form if the ingredients exist.
      b. More difficult to circumnavigate due to its size
      c. A line of thunderstorms can extend laterally for hundreds of miles. New cells continually reform at the leading edge and the line can persist for many hours as long as the necessary ingredients exist. These are often too high to fly over, too long to fly around and too dangerous to fly under (the storms in the line can also be supercells)
   iii. Supercell
      a. A dangerous convective storm that consists of primarily a single, quasi-steady rotating updraft that persists for an extended period of time. It has a very organized internal structure that enables it to produce especially dangerous weather for pilots who encounter them (updrafts may reach 9,000 fpm). A supercell may persist for hours; new cells will continue to form as long as the necessary ingredients exist

D. Hazards
   i. Lightning, strong wind, downburst, turbulence, icing, hail, rapid altimeter changes, static electricity, tornado
   ii. Microbursts
      a. The most severe type of wind shear
         - Associated with convective precipitation into dry air at cloud base
      b. Typical Microburst
         - Horizontal diameter of 1-2 miles
         - Depth of 1,000’
         - Lifespan of 5-15 minutes
         - Downdrafts of up to 6,000 feet per minute
         - Headwind losses of 30-90 knots (seriously degraded performance)
         - Strong turbulence and hazardous wind direction changes
      c. Flying through a Microburst
         - During an inadvertent takeoff into a microburst, the plane may first experience a performance-increasing headwind (1)
         - Followed by performance-decreasing downdrafts (2)
         - Followed by a rapidly increasing tailwind (3)
            a This can result in terrain impact or flight dangerously close to the ground (4)

- An encounter during approach involves the same sequence of wind changes and could force the plane to the ground short of the runway



d. Indications
- Visual
  - a Intense rain shaft at the surface, but virga at cloud base
  - b Ring of blowing dust
- Alerting Systems
  - a The FAA has invested in substantial microburst accident prevention
  - b LLWAS-NE, TDWR, and ASR-9 WSP systems installed at major airports
    1. Very few false alerts, and detect microbursts well above 90% detection rate requirement established by congress
  - c Many airports, especially smaller airports, have no wind shear systems
    1. Aviation Weather Handbook (FAA-H-8083-28) – See Ch. 22.7.3 Downburst & Microburst
       a. Includes information on how to recognize the risk of a microburst encounter, how to avoid an encounter, and the best strategy for escape

e. Avoiding Microbursts/Wind Shear
- Do not takeoff if wind shear is in the area
- Never conduct traffic pattern operations near an active thunderstorm
- LLWAS (Low Level Wind Shear Alerting System), if available, can warn of impending wind shear
- PIREPS: Can be very informational/helpful if a pilot has reported wind shear in the area
- If unable to avoid, follow manufacturer's procedures
  - a General procedures include max power, pitch aggressively for max climb (do not stall)

9. Frost & Icing AI.III.C.K3i, AI.III.C.K3k

A. Frost
  i. On cool, clear nights, the temperature of the ground and objects on the surface can cause temperatures of the surrounding air to drop below the dew point. When this occurs, the moisture in the air condenses and deposits itself on the ground, buildings, and other objects like aircraft
     a. The moisture is dew. If temperature is below freezing, the moisture is deposited in the form of frost
     b. While dew poses no threat to aircraft, frost poses a definite flight safety hazard
        - Disrupts the smooth airflow over the wing and can drastically reduce lift. It also increases drag, which when combined with lowered lift production, can adversely affect the ability to takeoff
  ii. An aircraft must be thoroughly cleaned and free of frost prior to beginning a flight

B. Types of Icing
  i. Rime Icing

a. Rough, milky, and opaque ice formed by the instantaneous freezing of small, super cooled water droplets after they strike the aircraft
b. Rime icing formation favors colder temperatures, lower liquid water content and small droplets. It grows when droplets rapidly freeze upon striking an aircraft. The rapid freezing traps air and forms a porous, brittle, opaque, and milky colored ice.

ii. Clear Icing
a. A glossy, clear, or translucent ice formed by relatively slow freezing of large, super cooled water droplets
b. Clear icing conditions exist more often in an environment with warmer temperatures, higher liquid water contents, and larger droplets
c. Clear ice forms when only a small portion of the drop freezes immediately while the remaining unfrozen portion flows or smears over the aircraft surface and gradually freezes
d. Clear ice is more hazardous than rime ice
- It tends to disrupt airflow considerably more than rime icing
- It is clear and more difficult to see and therefore can be difficult to recognize
- It is difficult to remove since it can spread beyond the deice/anti-ice capabilities

iii. Mixed Icing
a. A mixture of clear and rime ice
b. Poses a similar hazard to an aircraft as clear ice

C. Hazards of Icing
i. Structural icing degrades engine performance
ii. It destroys the smooth flow of air over the wing, increasing drag while decreasing the ability to create lift
a. As power is added to compensate for the additional drag, and the nose is lifted to maintain altitude, the angle of attack is increased allowing the underside of the wings & fuselage to accumulate additional ice
b. Wind tunnel and flight tests have shown that ice accumulations no thicker than a piece of coarse sandpaper can reduce lift by 30% and increase drag by 40%
- Larger accretions can reduce lift even more and increase drag by 80% or more.
c. Aircraft may stall at much higher speeds and lower angles of attack than normal
iii. The actual weight of ice on an aircraft is insignificant when compared to the airflow disruption it causes

D. Freezing Level
i. Be alert for icing anytime the temperature approaches 0 degrees Celsius and visible moisture is present
ii. When carried above the freezing level, water becomes supercooled
a. Supercooled water freezes on impact with an aircraft
- When the temperature cools to about -15^{o} C, much of the remaining water vapor sublimates as ice crystals. Above this level, the amount of supercooled water decreases
b. Clear icing can occur at any level above the freezing level, but at high levels icing from smaller droplets may be rime or mixed rime and clear ice
c. The abundance of large, supercooled water droplets makes clear icing very rapid between 0 & -15^{o} C

10. Fog & Mist AI.III.C.K3j

A. Fog
i. A visible aggregate of minute water droplets that are based at the surface and reduce visibility to less than 5/8 statute mile. Differs from cloud only in that it's base must be at the surface

B. Types of Fog
i. Radiation Fog
a. Produced over a land area when radiational cooling reduces the air temperature below its dew point
- Generally, a nighttime occurrence and often does not dissipate until after sunrise

- Terrestrial radiation cools the ground, the ground cools the air and when the air reaches its dew point, fog forms

b. Factors favoring formation: Shallow surface layer of relatively moist air beneath a dry layer, clear skies, and light surface winds
- Restricted to land because water surfaces cool little from nighttime radiation.
- Fog is shallow when wind is calm
  - a Winds up to about 5 knots mix the air slightly and tend to deepen the fog by spreading the cooling through a deeper layer
  - b Stronger winds disperse the fog or mix the air through a still deeper layer with stratus clouds forming at the top of the mixing layer

c. Ground fog usually burns off rapidly after sunrise. Other radiation fog generally clears before noon (unless clouds move in over the fog)

ii. Mountain/Valley Fog

a. Ground cools overnight and the denser, cooler mountaintop air sinks into valleys and collects there

b. Through the night, the valley fills from the bottom with cold layers of air (known as "cold air drainage")
- Cooler air lowers surrounding temperatures toward the dewpoint/saturation
- If there is sufficient moisture, fog forms in the valleys

c. Most common in fall and spring

d. Densest around sunrise when surface temperatures are the lowest

iii. Advection Fog

a. Moist air moves over a colder surface, cooling the air to below its dew point
- Most common along coastal areas, but often moves deep in continental areas.
- Deepens as wind speed increases up to 15 knots; winds much stronger than 15 knots lifts the fog into a layer of low stratus or stratocumulus clouds.
- West coast of the US is quite vulnerable to advection fog which frequently forms offshore because of cold water and then is carried inland by the wind.
  - a Can remain for weeks, moving over land at night and retreating over water in the morning

b. A pilot will notice little difference flying over advection and radiation fog

iv. Upslope Fog

a. Forms as a result of moist, stable air being adiabatically cooled to or below its dewpoint as it moves up sloping terrain

b. Wind speeds of 5-15 knots are most favorable; stronger winds tend to lift the fog into a low layer of stratus clouds

c. Common along the eastern slopes of the Rockies, and somewhat less frequent east of the Appalachians
- Often quite dense and extends to high altitude

v. Frontal Fog

a. Formation
- When warm, moist air is lifted over a front, clouds, and precipitation may form
- If the cold air below is near its dewpoint, evaporation may saturate the cold air and form fog
- Result is a continuous zone of condensed water droplets from the ground through the clouds

b. Mostly associated with warm fronts but can occur with others as well.

c. Can be quite dense and continue for an extended period

vi. Steam Fog

a. When very cold air moves across relatively warm water, enough moisture may evaporate from the water surface to produce saturation. As the rising water vapor meets the cold air, it immediately

recondenses and rises with the air being warmed from below. Because the air is destabilized, fog appears as rising streamers that resemble steam
- b. Steam fog is often very shallow; as the steam rises, it reevaporates in the unsaturated air above
- c. Expect convective turbulence flying through it

vii. Freezing Fog
- a. Tiny, supercooled liquid water droplets in fog freeze instantly on exposed surfaces when temperatures are at or below freezing
- b. Can form on the aircraft, making flight very dangerous if not removed

C. Mist
- i. Visible aggregate of minute water droplets of ice crystals suspended in the atmosphere that reduces visibility to less than 7 SM, but greater than, or equal to, 5/8 SM
- ii. Forms a thin grayish veil covering the landscape
- iii. Intermediate between fog and haze
  - a. Lower relative humidity than fog and doesn't obstruct visibility to the same extent

11. Obstructions to Visibility AI.III.C.K3l

A. Haze
- i. Suspension in the air of extremely small particles individually invisible to the eye, but numerous enough to give the air an opalescent appearance
  - a. Reduces visibility by scattering shorter wavelengths of lights
- ii. Produces bluish color when against a dark background and yellowish against a light background
  - a. Versus mist which only yields gray
- iii. Occurs in stable air and is usually only a few thousand feet thick, but may extend upwards of 15,000'
- iv. Visibility varies greatly depending on whether you're facing into or away from the sun

B. Smoke
- i. Suspension of small particles in the air produced by fires, industrial burning, etc.
  - a. May transition to haze after traveling 25-100 miles and the larger particles have settled
- ii. Can reduce visibility to zero and contains many highly toxic compounds, like carbon monoxide (CO)
- iii. Must be dispersed by movement of air

C. Volcanic Ash
- i. Made up of fine particles of rock powder from a volcano
  - a. Ash is composed of silica (glass)
  - b. Eruptions can send ash into the upper atmosphere
- ii. Ash may not be visible at night or in IMC, even if visible, it's hard to distinguish from ordinary clouds
  - a. Use aviation reports for ash clouds
- iii. Very hazardous to aircraft
  - a. Jet engine: Ash turns to a soft, sticky molten adhering to the engine parts
    - Without air in the engine, the engine flames out
    - Exiting the ash cloud, the silica becomes dislodged, and the engine can attempt a restart
  - b. Piston aircraft: Less likely to lose power, but severe engine damage is likely
  - c. Causes abrasive damage
    - Particles impacting the windshield can sandblast it into a frosted finish obscuring visibility
      - a Also removes paint and pit metal on the nose and leading edges
    - Contaminates aircraft ventilation, hydraulic, instrument, electronic and air data systems

D. Blowing Snow
- i. Snow lifted from the surface by the wind to a height of 6' or more
- ii. Reduces horizontal visibility to less than 7 SM
- iii. Whiteout: Strong winds keep the snow suspended up to 50' or so, obscuring the sky and reducing visibility to near zero

        iv. Visibility improves rapidly when the wind subsides
    E. Dust Storms, Sandstorms, & Haboob
        i. Dust Storms
            a. Severe weather condition characterized by strong winds and dust-filled air over an extensive area
            b. Originate over regions when fine-grained soils, rich in clay and silt, are exposed to strong winds
                - Commonly found in dry lake beds, river flood plans, ocean sediments and glacial deposits
                - Most common in the Southwest US
            c. Reduce visibility to near zero
            d. Creation & Dissipation
                - Extreme heating of barren ground + turbulent unstable air mass
                    a Surface winds 15 knots or greater (35 knots over desert rock fragments)
                    b Average height is 3,000 to 6,000', but they can reach up to 15,000'
                - Strong cooling after sunset settles the dust (temperature inversion)
                    a Without turbulence, dust settles at a rate of 1,000' per hour (can take hours or days to settle)
            e. Hazards
                - Visibility can drop to zero in a matter of seconds
                - Dust can clog intakes, damage systems, and affect human health
                - Slant range visibility is greatly reduced compared to report surface visibility
                    a May not be possible to see an airport from above even if surface visibility is 3 SM or more
        ii. Sandstorms
            a. Particles of sand carried aloft by a strong wind
            b. Similar to dust storms but on a more localized level since the sand particles are heavier
                - 10' to 50' above the ground
        iii. Haboob
            a. Dust storm that forms as cold downdrafts from a thunderstorm lift dust and sand into the air
            b. Often short lived, but can be intense
                - Dust wall can extend for 60 miles and rise to the base of the thunderstorm
                - Lage dust/sand whirls frequently form along the edge of the turbulent cold air outflow

12. Importance of a Thorough Weather Briefing
    A. FAR 91.103 – As PIC, you are required to become familiar with the weather reports and forecasts
    B. The weather briefing allows the pilot to make a more educated and competent go/no go decision
        i. Alerts the pilot to any potentially hazardous conditions along the route of flight while providing a big picture overview of the conditions prior to stepping foot in the airplane
        ii. More specific information is also attained
        iii. The weather briefing can go beyond just weather, providing the pilot information on NOTAMs, ATC delays, and other information that may affect the flight
    C. The pilot knows what to expect and can be alert to any changing conditions while enroute

13. Weather Information Sources AI.III.C.K1
    A. General awareness of the overall weather
        i. Internet, Weather Apps, TV, etc.
    B. Detailed Briefing (Specific to the flight)
        i. FSS (1-800-WX BRIEF or 1800wxbrief.com)
            a. Primary source for preflight weather
            b. Provides NOTAM, weather, and filing of flight plans
        ii. NWS – National Weather Service
            a. Aviationweather.gov

b. Provides weather only (vs FSS with NOTAM, and filing of flight plans)
iii. ForeFlight
a. Briefings are timestamped and stored to comply with FAR 91.103
iv. Self-Brief (AIM 7-1-2-C)
a. Pilots can receive a regulatory compliant briefing without contacting flight service
b. Encouraged to use automated resources & review AC 91-92 – Pilot's Guide to a Preflight Briefing
- Provides a roadmap for self-briefings and guidance for FAR 91.103 required preflight actions
- Briefing types and sources, sample preflight checklists, Do's and Don'ts, and more

C. RM: Inflight Weather Sources
i. FSS Frequencies
a. Provides information/services before, during, and after flights,
b. Unlike ATC, FSS is not responsible for giving instructions, clearances or providing separation
c. Frequency is as published, or 122.2
ii. ForeFlight, or other apps (with data connection)
iii. Satellite Weather
a. Current weather available to appropriately equipped aircraft
- i.e. G1000 with XM WX satellite capability and subscription

iv. FIS-B
a. Flight Information Service Broadcast – Part of the ADS-B system
b. Available to aircraft who can receive 978 MHz (UAT) flying within ADS-B coverage
- Automatically transmits a wide range of weather products to all aircraft equipped to receive the data, and flying within ADS-B coverage
- Includes AIRMET, Convective SIGMET, SIGMET, METAR, SPECI, National NEXRAD, Regional NEXRAD, D-NOTAM, FDC-NOTAM, PIREP, SUA Status, TAF, AMEND, Winds and Temperatures Aloft, TIS-B Service Status, Lighting, Turbulence, Icing, Cloud Tops, Graphical AIRMET, Center Weather Advisory

c. Capability and availability will vary based on individual ADS-B avionics

14. Weather Reports and Charts

A. METAR, TAF, and GFA AI.III.C.K2a, AI.III.C.K2c, AI.III.C.K2d
i. METAR (Aviation Routine Weather Report)
a. Observation of current surface weather reported in a standard international format
b. Contains the following information:
- **Type of Report** – 2 types:
  a Routine METAR report, transmitted hourly
  b Aviation selected special weather report (SPECI)
    1. Published when necessary to update a METAR for changing weather, mishaps, etc.
- **Station Identifier** – Four letter code (ex. KAHN). K is the country ID and AHN is the airport ID
  a Alaska begins with "PA" and Hawaii begins with "PH"
- **Date and Time of Report** – (161753Z) Six-digits: First 2 digits are date; last 4 are time (UTC)
- **Modifier** – Denote that the METAR came from an automated source or was corrected
  a "AUTO" indicates the report came from an automated source
  b "AO1" and "AO2" indicate the type of precipitation sensors at the station
  c "COR" identifies a corrected report.
- **Wind** – (14021G26)
  a Reported with 5 digits unless speed is > 99 knots, then it is 6
    1. The first 3 digits indicate wind direction in tens of degrees
    2. The last 2 digits indicate the speed of the wind in knots

a. Gusting winds (G) show with the peak gust after the "G"

3. If wind varies more than 60 degrees and the speed > 6 knots, a separate group of numbers, separated by a "V" (variable) will indicate the extremes of the directions

- **Visibility** – (3/4SM)
  - a Reported in statute miles
  - b RVR is sometimes reported following the visibility
    1. RVR is the distance a pilot can see down the runway in a moving aircraft.
    2. Shown with an "R" then the runway number, a slant, and the visual range in feet
- **Weather** – (-RA BR) Two different categories: Qualifiers and Weather Phenomenon
  - a Qualifiers show intensity or proximity as well as descriptor codes
    1. Ex: -, +, VC, SH, TS, FZ, etc.
  - b Phenomena describe the different precipitation, obscuration, and other phenomena
    1. Ex: DZ, RA, HZ, SS, DS, SN, etc.
- **Sky Condition** – (BKN008 OVC012)
  - a Always reported in the sequence of amount, height, and type
    1. Heights are depicted with three digits in hundreds of feet above ground
       a. Clouds above 12,000 ft. are not detected
    2. TCU and CB clouds are reported with their height
       a. Amount of sky coverage is reported in eighths of the sky from horizon to horizon

Sky Cover	< 1/8 Clear	1/8 – 2/8 Few	3/8 – 4/8 Scattered	5/8 – 7/8 Broken	8/8 Overcast
Contraction	**SKC/CLR/FEW**	**FEW**	**SCT**	**BKN**	**OVC**

- **Temperature and Dewpoint** – (18/17)
  - a In degrees Celsius (Temp below 0 degrees Celsius are preceded by the letter "M")
- **Altimeter Setting** – (A2970)
  - a Preceded by the letter "A" and reported as inches of mercury in a four-digit number
  - b "PRESRR" or "PRESFR" represent rising or falling pressure
- **Remarks** – RMK
  - a May include wind data, variable visibility, begin/end times of phenomenon, pressure info, and various other necessary info

EXAMPLE:
METAR BTR 161753Z 14021G26 ¾SM –RA BR BKN008 OVC012 18/17 A2970 RMK PRESFR

EXPLANATION:
Type of Report: Routine METAR
Location: Baton Rouge, Louisiana
Date: 16th day of the month
Time: 1753 Zulu
Modifier: None shown
Wind Information: Winds 140 at 21 knots gusting to 26 knots
Visibility: ¾ SM
Weather: Light rain and mist
Sky Conditions: Skies broken 800 ft., Overcast 1,200 ft.
Temperature: Temp 18 degrees C, Dewpoint 17 degrees C
Altimeter: 29.70 in. Hg.
Remarks: Barometric pressure is falling

ii. Terminal Aerodrome Forecast (TAF)

a. A terminal aerodrome forecast is a report established for the 5 s.m. radius around an airport
b. Valid for a 24-hour or 30-hour period, updated four times a day: 0000Z, 0600Z, 1200Z, 1800Z
c. The TAF utilizes the same descriptors and abbreviations as the METAR.
d. Includes the following information in sequential order:
- **Type of Report** – Can either be a routine forecast (TAF) or an amended forecast (TAF AMD)
- **ICAO Station Identifiers** – (KAHN) Same as METAR
- **Date and Time of Origin** – Six number code. First 2 are the date; last four are the time (UTC)
- **Valid Period Date and Time** – Six-digit number group. First 2 are the date, the next 2 are the beginning time for the valid period and the last 2 are the end time
- **Forecast Wind** – Wind direction and speed forecasts are given in a five-digit number group
- **Forecast Visibility** – Given in statute miles (Greater than 6 SM is shows as “P6SM”)
- **Forecast Significant Weather** – Same as a METAR (No sig weather forecast “NSW” shown)
- **Forecast Sky Condition** – Given same as the METAR. Only “CB” clouds are forecast
- **Forecast Change Group** – For any significant weather change forecast to occur, the expected conditions and time period are included, this information can be shown as:
  a FM - From - A rapid/significant change, usually within an hour, is expected
  b BECMG - Becoming - A gradual change is expected over no more than 2 hours
  c TEMPO - Temporary - Temporary fluctuations expected to last less than an hour
- **Probability Forecast** – Probability (%) of thunderstorms/precipitation in the coming hours

EXAMPLE:
TAF
KPIR 111130Z 111212 15012KT P6SM BKN090
TEMPO 1214 5SM BR
FM1500 16015G25KT P6SM BKN080 OVC150 PROB40 0004 3SM TSRA BKN030CB
FM0400 1408KT P6SM SCT040 OVC080 TEMPO 0408 3SM TSRA OVC030CB
BECMG 0810 32007KT=

EXPLANATION
Routine TAF for Pierre, South Dakota. On the 11th day of the month, at 11:30Z. Valid for 24 hours from 1200Z on the 11th to 1200Z on the 12th. Wind from 150 at 12 knots. Greater than 6 SM visibility. Broken clouds at 9,000 ft.
Temporarily, between 1200Z and 1400Z, visibility 5 SM in mist.
From 1500Z winds from 160 at 15 knots, gusting to 25 knots. Visibility greater than 6SM, and clouds broken at 8,000 ft., overcast at 15,000 ft. Between 0000Z and 0400Z, there is a 40 percent probability of visibility 3 statute miles, thunderstorms with moderate rain showers, clouds broken at 3,000 feet with cumulonimbus clouds.
From 0400Z winds are from 140 at 08 knots, visibility greater than 6 SM. Clouds at 4,000 ft. scattered and overcast at 8,000’. Temporarily between 0400Z and 0800Z, visibility 3 SM, thunderstorms with moderate rain. Clouds overcast at 3,000 ft. with cumulonimbus clouds.
Becoming between 0800Z and 1000Z, wind from 320 at 7 knots. End of report =

iii. Graphical Forecasts for Aviation (GFA) – replaced the Area Forecast (FA)
a. GFA Tool – Aviationweather.gov/gfa
b. Tools
- GFA User’s Guide - Weather.gov
- GFA Tutorial Video – Youtube.com
- Product Description Doc – National Weather Service

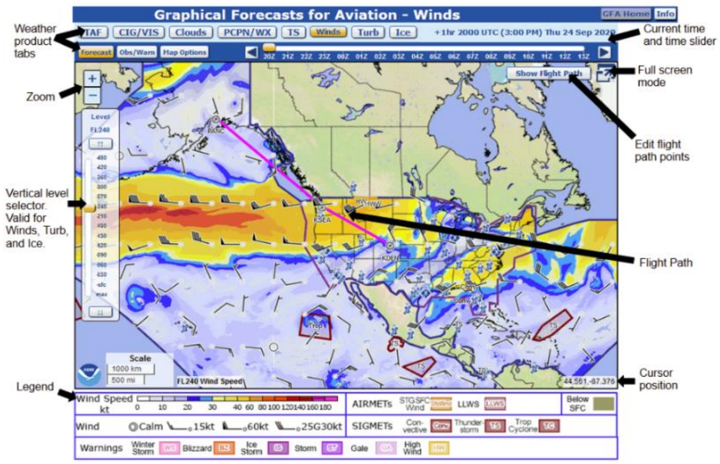
c. Scope
- Set of web-based displays intend to give a complete picture of weather that may affect a flight

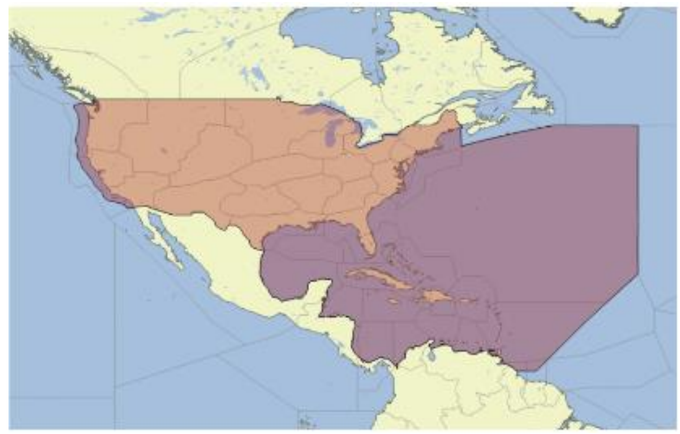
a Includes observational data, forecasts, and advisories including:
1. Thunderstorms, clouds, flight category, precipitation, icing, turbulence, and wind

- Describe s conditions produced by weather systems such as high- and low-pressure areas, air masses, and fronts. Predicts conditions that may affect flight over relatively large areas

d. Purpose
- Provides a forecast for the enroute phase of flight and for locations without a TAF
- Provide the ability to obtain forecast data previously available from the area forecast

e. Description
- Web-based displays providing observations/forecasts of safety critical weather phenomena
- Covers continental US, Gulf of Mexico, Caribbean, portions of the Atlantic (shown below)





- Includes observational data, forecasts, and warnings
  a Can be viewed from 14 hours in the past to 15 hours in the future
- Hourly model data and forecasts, including information on clouds, flight category, precipitation, icing, turbulence, wind, and graphical output are available
  a Wind, icing and turbulence forecasts are available in 3,000 ft. increments from the surface up to 30,000' MSL, and 6,000' increments from 30,000 MSL to FL 480
  b Turbulence forecast graphics for LO (below 18,000 MSL) and HI (FL180 and above)
  c A maximum icing graphic and maximum wind velocity graphic are also available

f. Advantages
- Displays for non-meteorologist users
- Single source for multiple products
- Temporal resolution 1 hour.
- Available continuously
- Updated continuously
- Display scalable and customizable

g. Limitations
- Not intended to cover every phenomenon
- No amendments
- Primarily low altitude products (below FL180)
- Automated; may not be as accurate as forecast with human involvement
- Displays may suffer from clutter
- Users may disable certain overlays, eliminating areas of hazardous weather

B. Model Output Statistics (MOS)
Note: Not required by the PTS/ACS, but becoming popular, especially on ForeFlight. If used/presented

during the checkride, the examiner may ask questions about it

i. What is it?
   a. Takes a weather model (big picture forecast) and applies statistical methods and historical observations to produce a specific point forecast (airport, town, etc.)
   b. Completely automated
      - Removes systematic model biases
      - Quantifies uncertainty – displays probability forecasts
      - Updated hourly
   c. Detailed prediction of temp, chance and type of precipitation/thunderstorms, cloud cover and height, wind speed and direction at specific points across the country
   d. Displayed and commonly used in ForeFlight

ii. Uses
   a. Forecasters use it to:
      - Create more accurate local forecasts
      - Construct and amend TAFs
   b. Better weather picture for aviation planning purposes
      - More detailed than GFA
      - More or less provides a TAF for airports that don't have TAF information
         a According to ForeFlight, TAFs cover 666 airports, MOS covers over 2100

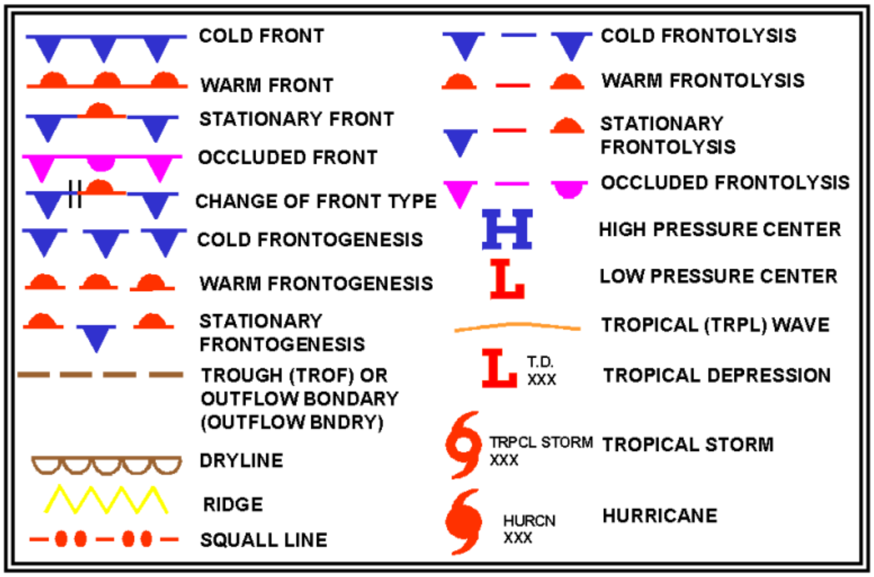
iii. Limitations
   a. Not a legal weather source
      - Great for planning, but should not be used for legal requirements
         a i.e., alternate requirements, required weather briefing, etc.
      - Used for guidance
   b. Cannot forecast
      - Multiple cloud layers
      - Forecast showers or fog in the vicinity
      - Precipitation intensity
      - Non-convective LLWS
      - No significant weather
      - Variable winds
   c. Can't discriminate between
      - Rain and drizzle
      - Mixed precipitation
   d. Currently only in the US

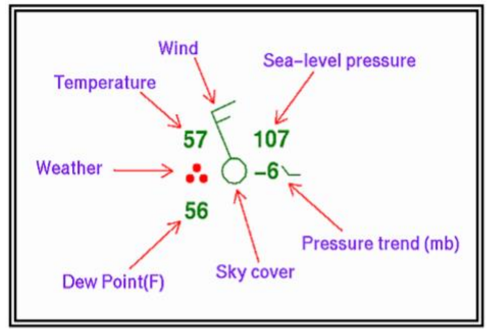
iv. Where to find it
   a. ForeFlight – Airport weather tab
   b. NWS MOS Text Bulletins
   c. Raw MOS data breakdown: JetStream Max: MOS
      - NWS resource if you're not using ForeFlight, or want to pull up and read raw MOS data

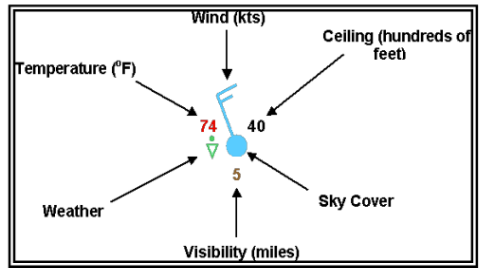
C. Surface Analysis Chart AI.III.C.K2b

i. Depicts an analysis of the current surface weather
ii. Computer prepared report transmitted every 3 hours covering contiguous 48 states/adjacent areas
iii. Variety of different charts showing high/low pressure, fronts, temp/dewpoint, wind direction/speed, weather, visual obstruction

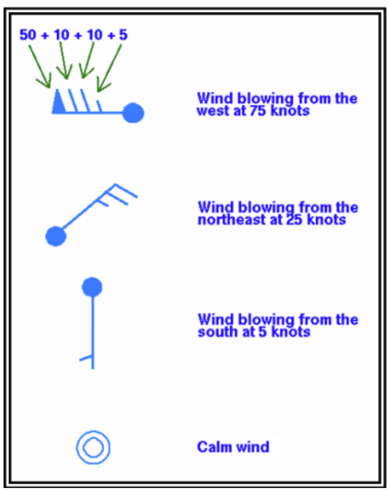
iv. Chart Symbols

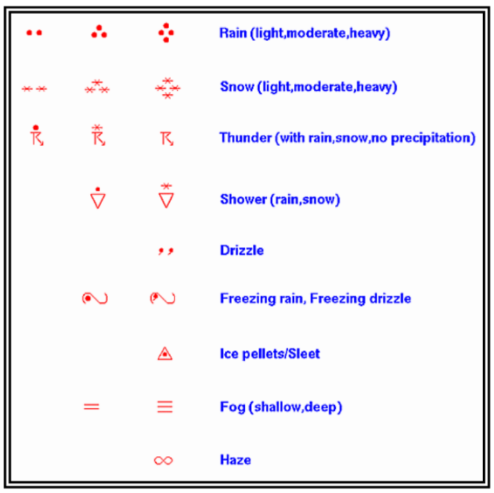


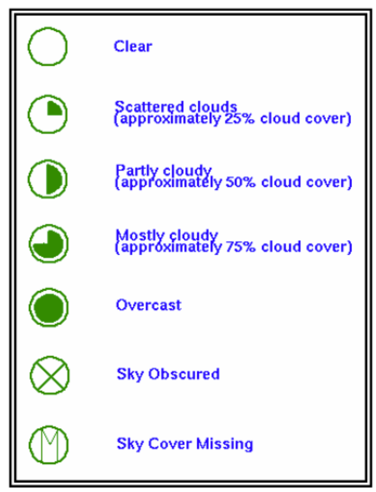




v. Surface weather observations for reporting points across the US can be depicted on this chart. Each reporting point is illustrated by a station model (NWS Plot Model is pictured top right, NWS aviation model pictured bottom right). A station model will include:



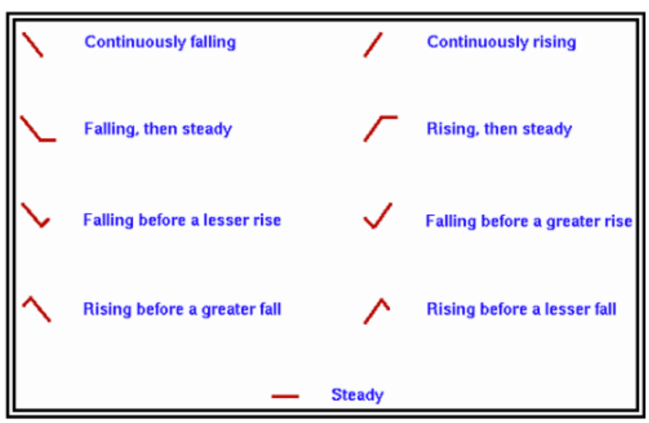




a. Type of Observation – Round indicates official weather observer, square is automated station

b. Sky Cover – Shown as clear, scattered, broken, overcast, or obscured/partially obscured

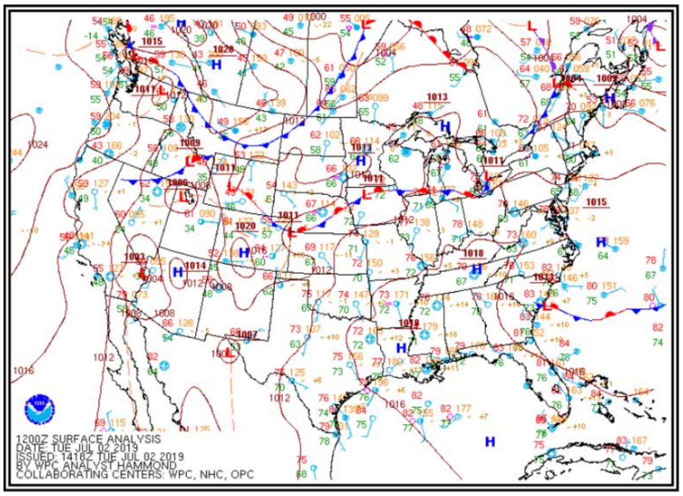
c. Clouds – Represented by specific symbols. Low cloud symbols are placed beneath the station model, middle and high cloud symbols are placed directly above the station model. Typically, only one type of cloud will be depicted with the station model.

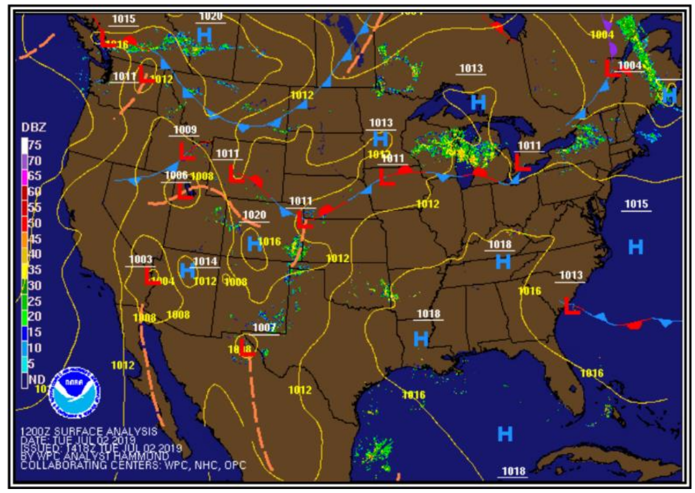


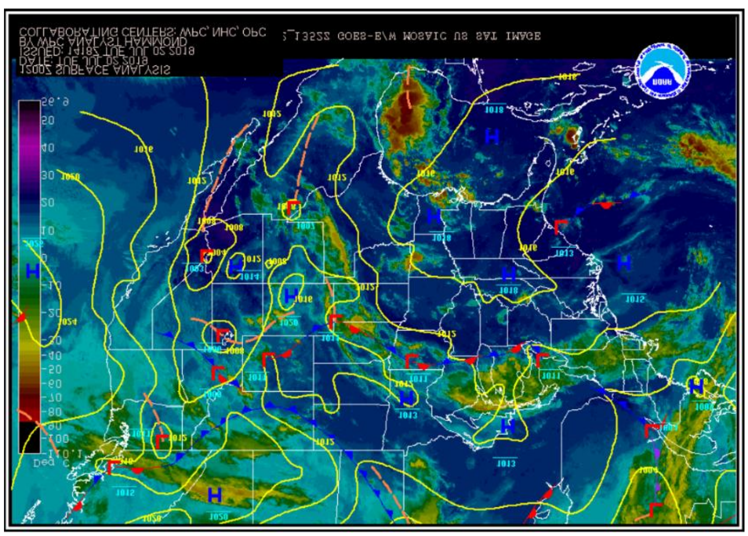
d. Sea Level Pressure (SLP) – Given in 3 digits to the nearest tenth of a millibar. For 1000 mbs or

greater, prefix a 10 to the 3 digits; for less than 1000 mbs, prefix a 9 to the 3 digits
- e. Pressure Change/Tendency – In tenths of mbs over the past 3 hours, shown directly below SLP
- f. Precipitation – Precip that has fallen over the last 6 hours to the nearest hundredth of an inch
- g. Dewpoint – In degrees Fahrenheit
- h. Present Weather – Depicted, right
- i. Temperature – Given in degrees Fahrenheit
- j. Wind – True direction of wind is given by the wind pointer line, indicating the direction from which the wind is coming (Short barb is 5 knots, long barb is 10 knots, a pennant is 50 knots)

vi. Example Charts







- a. Top Left: Surface analysis with surface observations
- b. Top Right: Surface analysis with radar composite
- c. Bottom: Surface analysis with satellite composite

D. Ceiling & Visibility Chart (CVA) AI.III.C.K2b

i. https://aviationweather.gov/gfa/#cigvis

ii. Use the Ceiling, Visibility, of Flight Category (Low IFR, IFR, Marginal IFR) drop down to provide a large-scale overview of ceiling and visibility information

- a. Drop down at top right (icon depicted to the right)
- b. Use the legend icon at the bottom right to view color meanings

iii. Combines satellite and surface observations to produce ceiling & visibility conditions across the US

a. Used for big picture planning and to avoid hazardous ceiling and visibility conditions
b. Useful for a knowledge of where VFR conditions should exist

E. Winds and Temperatures Aloft Forecast (FB) AI.III.C.K2e

i. Provide wind and temperature forecasts for specific locations
ii. The forecasts are made twice a day based at 0000Z and 1200Z
iii. Through 12,000 ft. are true altitudes and above 18,000 ft. are pressure altitudes
iv. Wind
   a. Direction is always in reference to true north and wind speed is always given in knots
   b. No winds are forecast when a given level is within 1,500 ft. of station elevation
   c. Wind direction and speed are listed together in a four-digit code
      - The first two numbers indicate the direction the wind is blowing from in tens of degrees
      - The second two numbers indicate the speed of the wind
   d. If wind is forecast to be 100-199 knots, 50 is added to direction/100 is subtracted from speed
      - To decode, the reverse must be accomplished
         a EX: For 7319 - Subtract 50 from direction, add 100 to speed to get 230º at 119 knots
   e. If the wind speed is forecast to be 200 knots or greater, the wind group is coded as 99 knots
      - EX: For 7799 - Subtract 50 from direction, add 100 to 99 to get 270 at 199 knots or greater
   f. Light and Variable wind is coded "9900"
v. Temperature
   a. Temperature is always given in Celsius
   b. No temperatures are forecast for any station within 2,500 feet of station elevation
   c. Temperatures above 24,000 feet MSL are negative.

EXAMPLE:

FD KWBC 151640
BASED ON 151200Z DATA
VALID 151800Z FOR USE 1700-2100Z
TEMPS NEGATIVE ABV 24000

FD	3000	6000	9000	12000	18000	24000	30000
AMA		2714	2725+00	2625-04	2531-15	2542-27	265842
DEN			2321-04	2532-08	2434-19	2441-31	235347

EXPLANATION:
The heading indicates that this FD was transmitted on the 15th of the month at 1640Z and is based on the 1200 Zulu radiosonde. The valid time is 1800 Zulu on the same day and should be used for the period between 1700Z and 2100Z. The heading also indicates that the temperatures above 24,000 feet MSL are negative. Since the temperatures above 24,000 feet are negative, the minus sign is omitted. A 4-digit data group shows the wind direction in reference to true north, and the wind speed in knots. The elevation at Amarillo, TX (AMA) is 3,605 feet, so the lowest reportable altitude is 6,000 feet for the forecast winds. In this case, "2714" means the wind is forecast to be from 270° at a speed of 14 knots. A 6-digit group includes the forecast temperature aloft. The elevation at Denver (DEN) is 5,431 feet, so the lowest reportable altitude is 9,000 feet for the winds and temperature forecast. In this case, "2321-04" indicates the wind is forecast to be from 230° at a speed of 21 knots with a temperature of -4°C.

F. Convective Outlook Chart AI.III.C.K2f

i. Overview
   a. Depicts areas forecast to have severe and non-severe (general) convection over 8 days
      - Severe: Tornado, wind gusts 50 knots or greater, or hail 1 inch diameter or greater
   b. Covers 8 days with 4 charts
      - Day 1 Chart, Day 2 Chart, Day 3 Chart, Days 4-8 Chart
   c. 5 levels of risk + general thunderstorm depict coverage and intensity of severe weather

d. Aviation Weather Convective Outlook Chart

ii. Levels of Risk (Day 1-3 Charts)
   a. Thunderstorm area (TSTM)
      - Areas of general thunderstorms
      - ≥ 10% probability of storms
   b. Marginal (MRGL) – Dark Green
      - Severe storms of limited organization / longevity or low coverage and marginal intensity
   c. Slight (SLGT) – Yellow
      - Organized severe storms expected, but usually in low coverage with varying intensity
   d. Enhanced (ENH) – Orange
      - Greater concentration of organized severe thunderstorms with varying levels of intensity
   e. Moderate (MDT) – Red
      - Potential for widespread severe weather with several tornadoes and/or numerous thunder
   f. High (HIGH) – Magenta
      - Severe weather outbreak is expected from numerous and long-track tornadoes or a long-lived derecho system with hurricane force winds producing widespread damage
         a Derecho: Widespread, long-lived, straight-line windstorm associated with a fast-moving group of severe thunderstorms

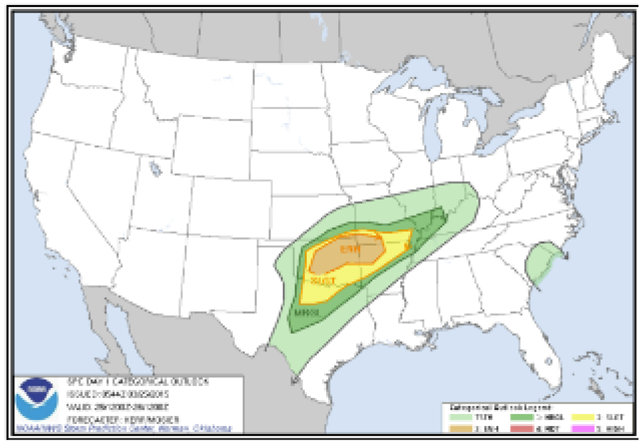


Figure 5-23. Categorical Outlook Legend for Days 1-3 Convective Outlook Graphic Example

   g. Day 4-8 Chart Depictions
      - Two probabilistic thresholds of 15% and 30% can be forecast
         a Highlighted areas are equivalent to slight, or enhanced on the Day 1-3 charts
      - If no 15% areas forecast, you'll see:
         a Predictability too low, or
            1. Severe storms may be possible, but the location is in doubt
         b Potential too low
            1. 15% or greater severe probabilities appear highly unlikely

iii. Additional Information
   a. Days 1 & 2: Contain individual severe probabilities for tornadoes, wind, and hail
   b. Day 3: Combined probability of all three types of severe weather
   c. Probabilities are within 25 miles of any point
   d. Probability requirements vary based on the day
      - Graphic Probability Requirements

iv. Issuance Schedule

Convective Outlook	Issuance Time (UTC)	Valid Period (UTC)
Day 1	0600	1200 – 1200
	1300	1300 – 1200
	1630	1630 – 1200
	2000	2000 – 1200
	0100	0100 – 1200
Day 2	0600 (Daylight Saving Time) 0700 (Standard Time)	Day 2/1200 – 1200
	1730	Day 2/1200 – 1200
Day 3	0730 (Daylight Saving Time) 0830 (Standard Time)	Day 3/1200 – 1200
Day 4-8	0900 (Daylight Saving Time) 1000 (Standard Time)	Day 4/1200 – Day 8/1200 (1 day intervals provided in graphic format on SPC Web page)

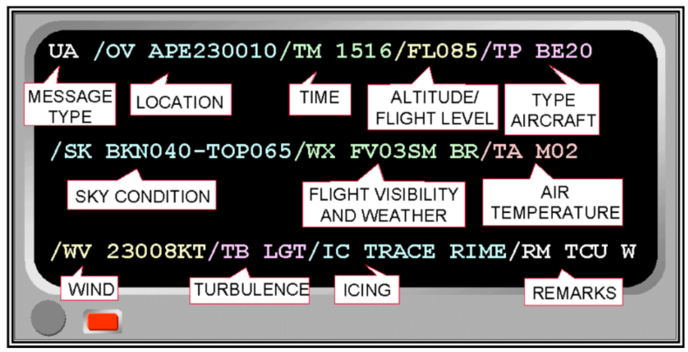
v. Using the chart
   a. A flight planning tool used to determine forecast areas of thunderstorms

15. **RM: In-Flight Weather Advisories** (RM: Inflight Weather Resources) AI.III.C.K2g, AI.III.C.R1c
   A. Forecasts that detail potentially hazardous weather
   B. AIRMET (WA)
      i. Issued every 6 hours with intermediate updates as needed
      ii. Info is of interest to all, but the weather section contains phenomena dangerous to light aircraft
      iii. 3 Types
         a. SIERRA: Denotes IFR and mountain obscurement
         b. TANGO: Denotes turbulence, strong surface winds, and low-level wind shear
         c. ZULU: Denotes icing and freezing levels
   C. SIGMET (WS)
      i. In flight advisory concerning non-convective weather that is potentially hazardous to all aircraft
      ii. Severe icing/extreme turbulence/Clear Air Turbulence (CAT) not associated with Thunderstorms; dust/sandstorms lowering visibility to less than 3 miles and volcanic ash
      iii. Unscheduled forecasts valid for 4 hours (hurricane SIGMET is valid for 6 hours)
   D. Convective SIGMENT (WST)
      i. Weather advisory issued for hazardous convective weather that affects the safety of every flight
      ii. Issued for:
         a. Severe Thunderstorms with
            - Surface winds greater than 50 knots
            - Hail at the surface ≥ ¾ inch in diameter
            - Tornadoes
         b. Embedded thunderstorms
         c. A line of thunderstorms
         d. T-storms with heavy or greater precipitation affecting at least 40% of a 3,000 mi^2 or greater area
   E. Center Weather Advisory (CWA)
      i. Unscheduled inflight, flow control, air traffic, and air crew advisory
         a. Not a flight planning product due by nature of its short lead time
      ii. Produced for weather beginning in the next 2 hours, and will be issued:
         a. As a supplement to existing SIGMET, Convective SIGMET or AIRMET
         b. When an inflight advisory has not been issued but weather conditions meet SIGMET/AIRMET criteria

based on pilot reports & reinforced by other meteorological conditions
   c. When observed or developing weather does not meet SIGMET, Convective SIGMET, or AIRMET criteria but pilot reports indicate the weather will adversely affect safe flow of air traffic

F. Inflight Weather Advisory Broadcasts
   i. ARTCCs broadcast Convective SIGMET, SIGMENT, or CWA once on all frequencies (not emergency) when any part of the area described is within 150 miles of their airspace

G. PIREPS AI.III.C.K2a
   i. A pilot generated report concerning meteorological phenomena encountered in flight
      a. Aircraft in flight are the only way to observe cloud tops, icing and turbulence
      b. Pilots can report any observation, good or bad, to assist other pilots with flight planning/preparation
   ii. PIREPS fill the gaps between reporting stations
   iii. Prepared using a prescribed format. Required elements include:
      a. Type, Location of the phenomena, Time, Altitude, Aircraft type, and at least one element to described reported phenomena
      b. Altitude: MSL
      c. Visibility: Statute miles
      d. Other distances: Nautical miles
      e. Time: UTC
   iv. Types of PIREPs
      a. Urgent (UUA)
         - Information about tornados, severe/extreme turbulence, severe icing, hail, LLWS within 2,000' of the surface, volcanic ash, any other phenomena considered to be hazardous
      b. Routine (UA)
         - Issued after receiving a report from a pilot that does not contain any urgent information



H. Other Inflight Weather Information
   i. Contact the nearest FSS to obtain an update to a previous briefing by radio
      a. Enroute advisories tailored to the phase of flight are available on request
   ii. RM: Onboard Weather Equipment AI.III.C.K4, AI.III.C.R2a
      a. Understand the operation and limitations of any onboard weather equipment
      b. ADS-B (Automatic Dependent Surveillance-Broadcast)
         - Free weather information on receivers that can receive the data
      c. FIS-B (Flight Information Services-Broadcast)
         - Free weather information on receivers that can receive the data
         - Wide range of weather products with national & regional focus
      d. Satellite weather

16. RM: Go/No Go Decision AI.III.C.R1

A. Weather factors must be considered in relation to the route of flight, aircraft, equipment, as well as the pilot
   i. Consider the PAVE checklist
      a. Can the plane and equipment handle the flight as planned?
      b. Is the route safe?
      c. Physical/Mental condition
         - Sick, tired, upset, depressed – These factors can greatly affect the ability to handle any problem
         - IMSAFE checklist

B. Set personal weather minimums and don't bend them AI.III.C.R1b, AI.III.C.R1c
   i. For example, numerous hazardous weather conditions may be an automatic no go

        a. Thunderstorms/squall lines, known or forecast icing, moderate or greater turbulence, fog, etc.
    ii. Personal limitations will vary based on the pilot and the aircraft
        a. These must always meet or exceed any FARs or aircraft limitations
        b. Ex: have personal crosswind limitations, visibility requirements, rest requirements, etc.

C. Recent Flight Experience
    i. Don't go beyond your abilities or the aircraft's abilities
    ii. Ensure currency and, more importantly, proficiency
    iii. Ex: Are you comfortable in MVFR if you haven't flown in a while

D. Recognizing Weather Hazards
    i. Interpretation of aviation weather charts, reports, etc.
        a. Preflight planning alerts the pilot to potential hazards
        b. Starts a few days prior to flight – as the flight approaches, the information becomes more detailed
    ii. Enroute updates and inflight reports alerts the pilot to changing conditions
        a. PIREPs, SIGMETs, METARs, LLWAS, ATC information/advice, weather tools (satellite, FIS-B), etc.
    iii. Visual indications
        a. Cloud formations, vertical development, strong wind, etc.

E. Flying is a continual process of decision making throughout the entire flight AI.III.C.R1a
    i. If you reach a "No Go" decision in flight, return home or divert, as necessary
    ii. Potential No Go Conditions: Reduced visibility (temp/dewpoint), hazardous weather (storms, icing, turbulence, etc.), Urgent PIREPs and/or routine PIREPs indicating poor conditions, conditions dropping below personal minimums, etc.

RM: Use & limitations of aviation weather reports and forecasts AI.III.C.R2b

The lesson as a whole is a discussion of these concepts

Conclusion:

Brief review of the main points

It is very important to be able to interpret and make a Go/No Go decision based on the information attained. A safe flight begins with a thorough weather briefing to ensure the pilot understands the meteorological factors that may affect the flight.

MANEUVER TO BE PERFORMED IN FLIGHT

IV.A. Maneuver Lesson

The evaluator asks the applicant to present a preflight lesson on the selected maneuver as the lesson would be taught to a student and determines the outcome of this Task before the flight portion of the practical test. Previously developed lesson plans from the instructor applicant's library may be used.

All necessary information for this lesson is found in sections VII through XII

ACS Requirements:

The applicant demonstrates instructional knowledge by describing and explaining:

1. Purpose of the maneuver.
2. Elements of the maneuvers and the associated common errors.
3. Desired outcome(s), including completion standards.

Deliver instruction on the selected maneuver using a lesson plan, teaching methods, and teaching aids, as appropriate.

PREFLIGHT PROCEDURES

V.A. Preflight Assessment

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of the elements related to a comprehensive preflight inspection. The learner will understand what to look for during each part of the inspection and can perform the preflight inspection as required by the checklist and the ACS.
Key Elements	1. Aircraft Specific Checklist 2. Airworthy and Safe 3. Fuel Grade and Contamination 4. *Oil Level (4-6 Quarts)
Elements	1. Big Picture Preflight 2. Preflight Inspection 3. Loading and Securing 4. Determining the Airplane is Safe
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can perform a comprehensive preflight inspection, understanding what to look for at each part of the inspection. The learner will be able to determine whether the airplane is airworthy and in a condition for safe flight.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

We don't want to find a problem with the airplane while we're in the air. For that reason, we perform a thorough preflight on the ground, allowing us to find and fix any problems before getting airborne, where issues are considerably more difficult to deal with.

Overview

Review Objectives and Elements/Key ideas

What

The preflight inspection is a thorough check of the airplane to ensure airworthiness and safety prior to flight.

Why

The accomplishment of safe flight begins with a careful preflight inspection which determines the airplane is legally airworthy, and that it is in a condition for safe flight.

How:

1. RM: **Big Picture Preflight** (PAVE Checklist)

- A. Pilot AI.V.A.K1, AI.V.A.R1
  - i. Mitigate risk by determining your own physical and mental readiness for flight - IMSAFE
    - a. Illness – Symptoms?
    - b. Medication – Taking any?
    - c. Stress – Family, money, relationships, work, etc.
    - d. Alcohol – Been drinking?
    - e. Fatigue – Well rested?
    - f. Emotion – Emotionally upset?
- B. Aircraft AI.V.A.R2
  - i. Required documents/inspection, preflight checklist
  - ii. Equipment and systems operation
  - iii. Proper loading (baggage, fuel, people, weight & balance)
  - iv. Performance capabilities
- C. enVironment AI.V.A.K4, AI.V.A.R3
  - i. Current and anticipated weather versus planned weather
    - a. Wind, clouds, density altitude, storms, frontal zones, icing, PIREPs, AIR/SIGMETs, etc.
  - ii. Terrain requirements & obstructions
  - iii. Departure, route selection, destination, alternate(s) (weather, terrain, airspace, TFRs, NOTAMs)
  - iv. Day or night
  - v. RM: Aviation security concerns - Congressional Research Service: Securing General Aviation AI.V.A.R5
    - a. Threats
      - Terrorists seek to exploit GA assets to attack critical infrastructure/high profile targets
      - Terrorists may exploit GA to gain knowledge and/or access to the US airspace system
    - b. Vulnerabilities
      - Minimal to nonexistent security at many small GA airports
      - Unattended airports

c. Mitigating GA Security Risks
- Airport watch program: Similar to a neighborhood watch; be alert
  - a Pilots, airport tenants, and workers report suspicious activity (1-866-GA SECURE)
  - b Call 911 if there is an immediate threat
- Limit airport access when able
  - a Don't provide flight line access to unauthorized people
  - b Ask to see required credentials if they're not visible
- Flights School Specific
  - a TSA computer-based flight school security awareness training program
    1. Annual requirement
  - b Background checks for prospective employees
  - c Formal written security procedures for employees and customers
  - d Display of employee identification
  - e Limit access to aircraft and their keys to authorized personnel
    1. Keep aircraft locked
    2. Monitor keys and secure/lock them up when away

D. External Pressures AI.V.A.R4
- i. Based on the particular flight
- ii. Stick to your standards and personal minimums – assess and attempt to mitigate risk

2. Preflight Inspection

A. Preflight Checklist
- i. Reasons for the Preflight Checklist
  - a. To ensure the plane meets airworthiness standards & is in a safe mechanical condition prior to flight
    - Airworthy: The aircraft and its components meet the airplane's type design or is in a properly altered configuration and is in a condition safe for operation
- ii. The POH must be the reference for conducting the visual preflight inspection
  - a. Chapter 4 of the POH
  - b. Each manufacturer has a specified sequence to follow for their specific aircraft
  - c. Using a different checklist will result in missing equipment and confusion
- iii. Always have the checklist to be used as a reference to ensure everything is checked
- iv. CE: Failure to use, or the improper use, of a checklist
- v. CE: Hazards which may result from allowing distractions to interrupt a visual inspection
  - a. Distractions can result in the pilot accidentally skipping steps/missing parts of the inspection
  - b. If distracted, the safest option is to start over. Otherwise, find a step you are sure has been completed and continue from there

B. Inspection Overview
- i. The preflight will logically move around the airplane to ensure it is in a condition for safe flight
- ii. It should begin while approaching the airplane on the ramp
  - a. Make a note of the appearance, looking for obvious problems
    - Gear out of alignment, structural distortion, skin damage, dripping fuel/oil leaks, etc.
- iii. Upon reaching the airplane, all tie downs, control locks, and chocks should be removed

C. What to Inspect AI.V.A.K3a, AI.V.A.K3b
- i. Inside the Flight deck
  - a. Airworthiness - Required Documents (AROW) & Inspections
  - b. Logbooks – To ensure the required tests and inspections have been completed AI.V.A.K3d
    Note: Logbooks are not usually kept in the airplane
    - Annual (91.409(a))

- 100-hour (91.409(b))
- Static/Transponder/Altimeter (every 24 months) (91.411 & 91.413)
- ELT (every 12 months) (91.207)
- Airworthiness Directives are complied with

c. Required equipment for the flight (Ex: Mode C transponder in Class B/C Airspace, Instruments)
d. Inspect the items inside the airplane (Instruments, Switches, Lights, Mixture, etc., as listed on the checklist)

ii. Outside the Airplane
a. Inspect the items outside the airplane (Structure, Controls, Engine, Prop, Gear, Struts, everything)
b. Defects are detected by following the checklist and looking for something wrong in each item
c. CE: Inability to recognize discrepancies to determine airworthiness
- Be familiar with the POH procedures, and know what you are looking at and looking for

D. Detecting Problems AI.V.A.K3c

i. Visible Structural Damage
a. Check for dents, cracks, bending, separating, etc.
- *Diamond aircraft cannot be flown if a dent is found due to the composite structure

b. Check for leaks/stains as they are signs of potential problems
c. Look for missing rivets, bolts, etc.
d. Inspect the propeller for damage including nicks and cracking

ii. Flight Controls
a. Ensure the flight controls move freely/correctly and are attached securely/properly
b. Check the flap movement and connections

iii. Fuel Quantity and Contamination
a. Quantity - Confirm the fuel quantity indicated on the gauge by a visual inspection, if possible
- Airplane attitude, gauge malfunctions, etc. can result in incorrect readings

b. Contamination
- Type, Grade of Fuel – Critical to safe flight
  - a Looking for 100LL (AVGAS) – Blue with a familiar gasoline scent
  - b Jet-A is clear, has a kerosene scent, and has disastrous effects when in reciprocating engines
    1. A reciprocating engine operating on jet fuel may start, run, and power the plane for enough time to become airborne only to fail catastrophically in flight
    2. The engine will be destroyed from detonation
       a. Detonation - The uncontrolled explosive combustion of the fuel/air mixture in the cylinder's combustion chamber
    3. Refueling trucks are marked with JET-A placards
  - c Supervise fueling to ensure the right type, and grade of fuel, and that the fuel caps are in place
  - d Never substitute a lower grade of fuel for a required higher grade (detonation will result)
    1. 80 is Red; 100LL is Blue; 100 is Green; Jet Fuel is Clear
- Water and Other Sediment – Usually from condensation in partially filled tanks or bad seals
    1. Water is heavier than fuel and therefore accumulates in the low points
    2. Prevented by minimizing the opportunity for condensation – fill the tanks after each flight, or at least after the last flight of the day
  - b Sediment can arise from dust/dirt entering the tanks
- Checking the Grade and Removing the Water and Other Contamination
  - a Drain the fuel from the gascolator/tank sumps checking for color, smell, water, and contamination
    1. Water is usually in bubble droplets, different in color, at the bottom of the sample

        2. If water/contaminants are found, drain until they have been removed

   iv. Oil Quantity and Contamination
      a. Check the oil level on the oil dip stick to ensure it is at an acceptable amount
         - The plane will use a small amount each flight, if a large amount is used there may be a problem
         - If the engine is cold, oil levels on the dipstick show higher than if the engine is warm and recently shutdown after a flight
            a Unless otherwise stated in the POH, a general rule is to check oil levels 15 mins or more after engine shutdown to allow oil to return to the sump
      b. Contamination can be detected by discoloration
         - Oil darkens as operating hours increase, however rapidly darkened oil be due to cylinder problems
   v. CE: Failure to ensure servicing with the proper fuel and oil
      a. Monitor the fueling process, when possible
      b. Always drain a sample of fuel to ensure the proper grade
      c. When adding oil, verify it is the type called for in the POH
      d. Improper fuel or oil can lead to engine problems, including failure
   vi. Leaks (Fuel, Oil, Hydraulic)
      a. Check to see there are no leaks under the airplane, inside the cowling, or on the wheel struts
      b. The fuel vent may appear to be a leak, but its purpose is to allow air into the tank or vent excess fuel depending on pressure differences
   vii. Ice and Frost
      a. Small amounts of ice/frost can disrupt the airflow over the wing, increase stall speed, and reduce lift
      b. Do not fly unless the ice/frost is removed in accordance with the requirements in the POH

3. Loading and Securing
   A. Ensure everything is properly loaded and secured prior to flight
      i. Verify the weight and balance calculations agree with the actual position loaded
         a. Ex. If the baggage was planned to be in the nose compartment but was loaded in the aft cargo
   B. Secure everything properly to prevent movement during flight
      i. This not only could damage the airplane, but could change the CG, or affect the pilot
   C. CE: Failure to ensure proper loading and securing of baggage, cargo, and equipment

4. Determining the Airplane is Safe AI.V.A.K2
   A. During the preflight inspection, note any issues to make an educated go/no go decision
      i. If there are any questions as to whether the airplane is safe, ask for help
         a. Find a Chief Instructor, CFI, Maintenance/AMP, etc.
         b. Don't take a plane that is probably safe
   B. Follow POH recommendations, as well as those learned from experience, to decide if the plane is safe for flight
      i. Do not let emotion, outside pressure, or any other undue influence sway you from doing what is safe
   C. For inoperative equipment, follow the procedures in III.B. Airworthiness Requirements and 91.213(d)
   D. Remember, FAR 91.3: PIC is directly responsible for, and the final authority as to, the operation of the aircraft

Common Errors:
- Failure to use or the improper use of a checklist
- Hazards which may result from allowing distractions to interrupt a visual inspection
- Inability to recognize discrepancies to determine airworthiness
- Failure to ensure servicing with the proper fuel and oil
- Failure to ensure proper loading and securing of baggage, cargo, and equipment

Conclusion:

Brief review of the main points
A safe flight begins with a thorough preflight as prescribed in the airplane's POH. This preflight inspection ensures the airplane is both airworthy and safe for flight.

V.B. Flight Deck Management

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of the elements related to flight deck management. The learner should maintain an organized flight deck and properly position all controls for correct use. All equipment should be fully understood to assist in utilizing all possible resources.
Key Elements	1. Good Housekeeping 2. Passenger Briefings 3. Internal and External Resources
Elements	1. Passenger Briefing 2. Arranging & Securing 3. Seat Position & Controls 4. Navigation Data Currency 5. Checklists Usage 6. Inoperative Equipment 7. Resource Utilization 8. Aviate, Navigate, Communicate 9. Case Study: Eastern 401
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can efficiently and safely complete a flight as described in flight deck management.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

All pilots need to learn to be good housekeepers. The airplane is your house, and you need to be sure it stays clean and organized.

Overview

Review Objectives and Elements/Key ideas

What

Flight deck management (single pilot resource management) is a process that combines you, the airplane, and the environment for safer and more efficient operations.

Why

Understanding the elements behind flight deck management (single pilot resource management) provides for a considerably more efficient and safer flight.

How:

1. **Passenger Briefing** (SAFETY) AI.V.B.K1
   A. **S**
      i. Seat belts for taxi, takeoff, and landing & Shoulder harnesses for takeoff and landing
         a. FAR 91.107 – Must brief passengers on how to fasten & unfasten their safety belt/shoulder harness
            - Cannot taxi, takeoff, land without ensuring safety belt/shoulder harness is fastened
      ii. Seat positioned and locked
   B. **A**
      i. Air vent location & operations
      ii. All environmental controls
      iii. Action in case of passenger discomfort
   C. **F**ire extinguisher location & operation
   D. **E**
      i. Exit doors (how to secure & how to open)
      ii. Emergency evacuation plan
      iii. Emergency/survival kit location & contents
   E. **T**
      i. Traffic – Scanning, spotting, notifying pilot
      ii. Talking – Sterile flight deck expectations
   F. **Y**our Questions?
   G. For more details, see the FAASafety Passenger Briefing Card
2. **The Flight Deck** AI.V.B.K4
   A. Seat Position & Controls
      i. Seat Belt/Harnesses should be comfortable and snug
         a. Shoulder harness must be worn at least for taxi, takeoff, and landing
         b. The safety belt must be worn all times at the controls
      ii. Seats
         a. On each flight, the pilot should be seated in the same position

b. Adjust height for the proper viewing height as directed in the POH
c. If the seat is adjustable, it is important to ensure that the seat is locked in position
   - Many accidents have occurred as the result of the seat suddenly moving

iii. Rudder Pedals
a. Knees should be slightly bent
b. With heels on the floor and balls of the feet on the pedals full movement should be available
c. Using toes, the brakes should be able to be actuated

B. Arranging
i. Ensure that all the necessary equipment, documents, checklists & navigation charts are on board
a. Materials should be neatly arranged and organized to make them readily available for use
ii. Any equipment with wires should not interfere with the motion or operation of any controls

C. Securing
i. Secure all cargo to prevent movement during flight
a. Loose cargo could be hazardous to people and/or aircraft CG/balance
ii. Check for loose articles which might be tossed about during flight, or in turbulence

D. Form the habit of "good housekeeping;" in the long run, it will pay off in safe and efficient flying

3. Navigation Data Currency AI.V.B.K3

A. Charts
i. FAR 91.103 requires each PIC to become familiar with all available information concerning that flight
a. Although it doesn't specifically require it, you should always carry current charts
ii. Information changes rapidly, out of date charts may be missing crucial information
a. Ex: Changes to airspace, new special airspace, change to procedures, frequencies, etc.
iii. To confirm currency, refer to the next scheduled edition date printed on the cover
a. Use the FAAs Dates of Latest Editions to verify you have the most current edition
b. Prior to expiration, check NOTAMs and Safety Alerts and Charting Notices for any changes

B. Database Currency
i. AIM 1-1-1b3(b): Databases must be maintained to the current update for IFR operations
a. No such requirements exist for VFR ops; however, it is always a good idea to keep a current database

C. Violations
i. It is not FAA policy to initiate enforcement action against a pilot for having an old chart or no chart, or for having an expired navigation database
ii. However, if a pilot is involved in an enforcement investigate and there is evidence that an out-of-date chart/database (or no chart) contributed to the situation, then that information could be used in any enforcement action that might be taken
iii. Bottom line, use current charts/databases

4. Checklist Usage AI.V.B.K2

A. Ensure the proper and orderly use of the manufacturer's checklist
i. Ensures every item is completed and checked in a logical order
ii. Don't go on memory, always backup your actions with a checklist
a. Sooner or later, you will make a mistake without a checklist

5. RM: Inoperative Equipment AI.V.B.R2

A. On the Ground
i. Perform a thorough preflight
ii. Follow FAR 91.213(d) procedures to defer & placard equipment as inoperative
a. See III.B. Airworthiness Requirements
iii. There should be no question as to what equipment is or isn't operative
iv. Consider the effects the inoperative equipment will have on the flight
a. Set and follow personal equipment minimums – just because it's legal, doesn't mean it's safe

- Ex: Inflight weather is not required by regs, but it could be hazardous without it on certain days
- If you're not comfortable with the state of the airplane, don't fly it

B. Airborne
   i. If equipment becomes inoperative, a decision must be made to continue or divert
   ii. Considerations
      a. Would the equipment prevent flying if it happened on the ground? FAR 91.213(d)
      b. How does it affect the remainder of the flight?
      c. How does it affect personal minimums?
      d. If I land somewhere with this inoperative equipment, can I return home?
      e. Other thoughts based on the situation

6. Resource Utilization

A. Resources can be found both inside and outside the flight deck. Think outside the box if necessary
B. Internal Resources
   i. POH, checklists (normal and emergency), charts
   ii. Satellite and/or app data, if equipped; documents loaded on a tablet
   iii. Equipment - A thorough understanding of the equipment is necessary to fully utilize all resources
   iv. Passengers can look for traffic, provide helpful information
   v. Ingenuity, knowledge, and skill
C. External Resources
   i. Maintenance technicians, and flight service personnel, 1800 WX Brief
   ii. Internet research (before flight – weather, NOTAMs, TFRs, airport procedures, etc.)
   iii. ATC – traffic advisories, vectors, emergency assistance, may even be able to contact someone
   iv. FSS can provide weather, airport conditions
   v. Other airplanes can provide PIREPs as well as radio communications
   vi. ASOS/AWOS can also provide weather conditions in flight
D. CE: Failure to utilize all resources required to operate a flight safely

8. RM: Aviate, Navigate, Communicate

A. Distractions
   i. RM: Passengers Distractions AI.V.B.R3
      a. Use the preflight briefing as an opportunity to explain passenger expectations, sterile cockpit, etc.
      b. If a passenger is distracting, explain the situation to them, and ask them to stop
   ii. Other Distractions
      a. They're dangerous, remove them from your view
   iii. Don't allow systems/equipment, people, inoperative systems to distract you from flying the airplane
B. RM: Automation & PEDs (RM: Use of systems or equipment, including automation & PEDs) AI.V.B.R1
   i. Ensure understanding of equipment, systems, automation, electronic devices
      a. Great tools for SA and reduced workload, but a lack of understanding can quickly distract from flying
   ii. Over reliance on automation & technology creates an environment where basic airmanship skills are eroded
      a. Understand their operation, use them, but be able to fly proficiently/safely without them

9. Case Study: Eastern 401

A. Multi-pilot airplanes have crashed due to minor distractions
B. Eastern Airlines 401 (December 29, 1972) crashed while the pilots were preoccupied with a light bulb and didn't realize the autopilot turned off
   i. FAA Lessons Learned
   ii. YouTube Video (15 mins)
   iii. Risk Management Concepts
      a. Overabundance of technology, loss of SA, distractions, systems understanding & malfunctions, task prioritization

    b. Discuss ways to mitigate these risks
C. Extremely important in a single pilot aircraft that you divide attention, avoid distraction, and maintain SA

Conclusion:
Brief review of the main points
By combining all the elements of flight deck management (single pilot resource management), the pilot will have a safer and more efficient flight due to a reduced workload and reduced mental stress and fatigue.

V.C. Engine Starting

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Reduction of Electrical System Failures Following Aircraft Engine Starting (AC 91-55), Cold Weather Operation of Aircraft - Cancelled (AC 91-13), POH/AFM

Objectives	The learner should develop knowledge of the elements related to engine starting as required in the ACS.
Key Elements	1. Checklist 2. Safety 3. Hand on the Throttle
Elements	1. POH Checklists 2. Safety Precautions 3. Normal Start Checklist 4. Atmospheric Conditions 5. Starting with External Power 6. Hand Propping Safety
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner shows the ability to safely start the engine using the appropriate checklist and understands different conditions and their effect on starting.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Starting the engine of an airplane is not as simple as starting the engine of your car. A plane can't just be turned on anywhere at any time, the proper precautions and procedures must be followed for safety reasons.

Overview

Review Objectives and Elements/Key ideas

What

Engine Starting discusses the safety precautions necessary when starting an airplane, the different conditions which affect starting the engine, as well as different ways to start the engine.

Why

Proper engine starting is necessary for the safety of people and property, as well as to prevent engine damage. There are certain situations which require special procedures, and some procedures can be dangerous. It is very important to know the proper engine starting procedures and precautions.

How:

1. **POH**
   A. Always use Manufacturer Checklists
      i. Ensures every item is completed and checked in a logical order
         a. Covers the Before Starting checklist and the Starting Engine Checklists
            - Especially important with different checklists for varying situations (Flooded, Cold, Normal, Hot, etc.)
      ii. Don't go on memory, always backup your actions with a checklist
         a. Sooner or later you will make a mistake without a checklist
   B. RM: Engine Starting Limitations AI.V.C.K3, AI.V.C.R3
      i. Check the Limitations section of the POH for applicable engine start limits
         a. Starter limits, cooling limits between starts, etc.
2. **RM: Safety Precautions** (RM: Propeller Safety) AI.V.C.R1
   A. Set the parking brake (ensuring they are pumped) and hold the brakes with your toes
      i. Look outside to ensure you are not moving
      ii. Too much heads down time (checklists, checking indications, etc.) can result in unrecognized movement and an accident or damage to the aircraft
   B. Ensure the ramp area surrounding the airplane is clear of persons, equipment, and other hazards
      i. Be aware of what is in front of, and behind the airplane
         a. Check all directions to ensure nothing is/will be in the vicinity of the propeller, or propeller blast
      ii. Propeller thrust can damage to property and injure people
   C. Anti-collision lights should be turned on prior to any start, at night use position lights too
   D. Always call "CLEAR" out of the side window and wait for a response from someone who may be nearby
   E. When activating the starter, the wheel brakes must be depressed
      i. Set the parking brake, if installed (and directed in the POH)
      ii. Proper brake application ensures the airplane does not lunge forward upon starting the engine
   F. Keep one hand on the throttle for prompt response if RPM is excessive or a hazardous situation presents itself
      i. Ensure the propeller area is clear of any obstructions (debris, people, obstacles, etc.)

   ii. Doublecheck the area behind the aircraft is clear

3. Normal Start Checklist

A. Review the normal start checklist in the POH

B. Engine Controls During Start

   i. Always keep one hand on the throttle to manage the initial engine starting speed
      a. After the engine is started, set the throttle to the RPM setting specified in the POH
      b. Other controls (mixture, prop, carb heat, boost pump, etc.) should be set/adjusted as specified in the POH/checklist
   ii. Monitor the oil pressure after engine start
      a. Ensure the pressure is increasing toward the POH specified value
         - If normal oil pressure is not reached and maintained, serious internal engine damage is likely
         - In most conditions, oil pressure should reach at least the lower limit within 30 seconds
      b. If oil pressure does not rise to the POH values in the specified time, shutdown the engine
   iii. Check all other instruments to ensure they are operating within limits
   iv. Avoid excessive engine RPM and temperatures
      a. Adjust the engine controls to maintain the POH recommended RPM, fuel, propeller, etc. settings
      b. Monitor the instruments and use the checklist if the engine temperature begins to rise abnormally

4. Atmospheric Conditions AI.V.C.K1

A. Cold Weather

   i. Low temperatures may cause a change in the viscosity of engine oils (they congeal, or become thicker), batteries may lose a higher percentage of their effectiveness, and instruments may stick
      a. Preheat of the engine(s) (and cabin) before starting is desirable
         - Preheat by storing the airplane in a heated hangar, if possible
         - Use only heaters that are in good condition and do not refuel the heater while it is operating
         - Do not leave the aircraft unattended and keep a fire extinguisher handy
         - Do not place the heat ducting so it will blow hot air directly on combustible parts of the aircraft (upholstery, canvas engine covers, flexible fuel, oil, and hydraulic lines)
   ii. Starting the Engine
      a. In moderately cold weather, preheat may not be necessary
         - Use care, oil may be congealed and turning the engine with the starter or by hand is difficult
            a If approved by the POH, the pilot may rotate the prop by hand to loosen the congealed oil
               1. Follow the POH procedures, and be positive the engine is OFF to avoid an accidental start
      b. Cold Engine Start Problems
         - Tendency to overprime, which washes down cylinder walls and may result in scoring of the walls
            a Also results in poor compression and consequently causes hard starting
            b Aircraft fires have been started by overpriming
               1. Have a fireguard/extinguisher ready
         - In a cold engine, icing over the sparkplug electrodes can cause problems
            a Engine only fires a few revolutions and then quits
               1. Sufficient combustion to cause water in the cylinders, but not enough to heat them up
               2. The water condenses on the sparkplug electrodes, freezes to ice, and shorts them out
            b Avoid prolonged idling
               1. Engines may quit because sufficient heat is not produced to keep the plugs from fouling out
            c The only remedy is heat
               1. If a heater is not available, the plugs should be removed from the engine and heated to the point where no moisture is present
   iii. Starting

a. Prime the engine with fuel first (over-priming can result in an aircraft fire – AC 91-13)
  - AC 91-13 is still available to read but has been cancelled and incorporated into various other ACs

b. After start, follow the POH procedures to allow the engine, and engine oil to warm and circulate
  - As mentioned, engines may quit with long idling

B. Hot Weather
  i. Hot Start procedures in the POH
    a. Generally, little to no priming is needed, but if the engine doesn't catch, use minimum priming
  ii. In the case of an overprimed engine (common with hot starts), use the flooded start checklist to clear the excess fuel and start the engine
  iii. Vapor lock (fuel injected engines)
    a. Fuel delivery lines tend to be on the top of the engine, directly over the cylinder fins
    b. Heat from the engine/outside can boil the fuel out of the lines creating vapor which prevents starting
      - Hot start generally attempts to purge/minimize the vapor in the system with the fuel boost pump

5. *Starting with External Power AI.V.C.K2, AI.V.C.R2

A. RM: Ensure proper use and understanding of the external power unit
  i. Follow steps in the owner's manual
  ii. Besides not being able to start the plane, there is the risk of damaging the unit or aircraft systems

B. In addition to those items in Section 4, Normal Operating Procedures, check the following items:
  i. Caution Lights (EPU) - Illuminated if power is available
  ii. During preflight, check that the EPU connector is inserted and secure

C. Before Engine Starting
  i. Engine Starting Checklist, plus:
    a. EPU Light: ON; EPU Switch: ON; Voltmeter: Check 12 - 14 Volts
  ii. Start the engine as normal (Cold/Warm/Flooded)

D. After Engine Start
    a. Select EPU switch to OFF: EPU light ON
    b. Signal ground crew to pull the EPU cord: EPU light OFF
    c. Master Switch (GEN): OFF and Check Battery Voltage: Approximately 12 volts
    d. Master Switch (GEN) ON and Check Battery Voltage: Approximately 14 volts
  ii. GEN warning light: Check OFF

6. RM: Hand Propping Safety (RM: Propeller Safety) AI.V.C.R1

A. Basic requirements BEFORE attempting a hand prop
  i. Do not hand prop unless two people, both familiar with hand propping techniques are available
    a. Never allow a person unfamiliar with the controls to occupy the pilot's seat when hand propping
  ii. The person pulling the propeller blades through directs all activity and is in charge of the procedure
    a. Chocks can be an additional precaution, or tie down the tail (Be careful removing them)
  iii. The second person must be seated in the plane to ensure the brakes are set, the controls are properly exercised, and to follow the direction of the person pulling the propeller
  iv. The ground surface near the prop should be stable and free of debris (otherwise relocate)
    a. Loose gravel, wet grass, mud, etc. might cause the person pulling the prop to slip into the blades
  v. Both participants should discuss the procedure and agree on voice commands and expected action

B. *Engine Starting Set-up
  i. The fuel system/engine controls (pump, primer, throttle, mixture) should be set for a normal start
  ii. Check to ensure the ignition/magneto switch is OFF
  iii. The descending prop blade should be rotated to a position slightly above horizontal
  iv. The person doing the propping should face blade squarely and stand less than an arm's length away
    a. Too far away and it would be necessary to lean forward in an unbalanced condition

C. *Procedures and Commands for Hand Propping

i. Person out front says, “GAS ON, SWITCH OFF, THROTTLE CLOSED, BRAKES SET”
    a. Person IN ensures - Fuel: ON, Mixture: RICH, Ignition: OFF, Throttle: CLOSED, Brakes SET, and repeats
ii. Person out front checks the brakes by pushing on the prop
iii. Person out front, after pulling the prop through to prime the engine says, “BRAKES AND CONTACT”
    a. Person in the pilot’s seat checks the brakes SET and turns the ignition switch ON, then repeats
iv. The propeller is swung by forcing the blade downward rapidly as hard as possible
    a. Push with the palms
        - If the blade is gripped tightly with the fingers, the person’s body may be drawn into the propeller blades should the engine misfire and rotate in the opposite direction
v. If it does not start, the prop should not be moved until certain the ignition/magneto switch is OFF

Conclusion:
Brief review of the main points
Always ensure safety when starting the engine.

V.D. Taxiing, Airport Signs, & Lighting

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of the elements related to taxiing an airplane as required in the ACS.
Key Elements	1. Fast Walk 2. Crosswind Corrections 3. Taxi Diagram
Elements	1. Taxi Instructions 2. Plan, Brief, Review 3. Appropriate Flight Deck Activities 4. Taxiing 5. Wind Corrections 6. Night Operations 7. Low Visibility 8. Runway Incursions 9. Airport Markings 10. Airport Signs 11. Airport Lighting & Visual Aids
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can safely maintain positive control of the airplane with the proper crosswind corrections. The learner understands the elements related to safely and effectively taxiing.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Taxiing is one of the basic skills required anywhere you fly. At some airports with many taxiways it can be intimidating and therefore is very important to understand how to safely and efficiently taxi an airplane.

Overview

Review Objectives and Elements/Key ideas

What

Taxiing is the controlled movement of the airplane under its own power while on the ground.

Why

Since the airplane is moved by its own power between the parking area and runway, the pilot must thoroughly understand and be proficient in taxi procedures.

How:

1. **Taxi Instructions** AI.V.D.K3
   A. Communicating with ATC (Big Picture)
      i. Always use standard ATC phraseology to facilitate clear and concise communication
      ii. When making initial contact, state who you are, where you are on the airport, what you want
      iii. Focus on the ATC clearance
         a. Don't perform any nonessential tasks while communicating with ATC
         b. RM: Eliminate expectation bias AI.V.D.R2
            - Don't assume you will be given the same clearance as before
      iv. Read back all clearances and verify the route/clearance on the taxi diagram
   B. Controlled Airports (AIM 4-3-18 Taxiing) AI.V.D.K7b
      i. Clearance is required:
         a. To taxi onto the movement area
            - Movement Area: Runways, taxiways, and other areas of an airport under ATC control
            - Non-Movement area: Loading ramps, parking areas/aprons not controlled by ATC
         b. To taxi on a runway, take off, or land when an ATC tower is in operation
         c. Prior to crossing any runway (ATC will issue an explicit clearance for *all* runway crossings)
      ii. Prior to entering the movement area, contact Ground control for a taxi clearance
         a. Frequencies & Procedures
            - Chart Supplement: Airport specific information
               a Airport remarks, frequencies, tower times of operation, etc.
            - Airport Diagram
               a Review for frequencies and airport familiarity
            - Check NOTAMs for changes, taxiway/runway closures, etc.
         b. Taxi Request
            - Aircraft identification, location, type of operation (VFR/IFR), first point of intended landing
            - Ex: "Washington ground, Beechcraft 123, at hangar 8, ready to taxi, IFR to Chicago"
      iii. When assigned a takeoff runway, ground will:
            - Specify the runway (or point to taxi to)

            - Issue taxi instructions
            - State any hold short instructions or runway crossing clearances
                a Does not authorize you to enter or cross the assigned departure runway at any point
            - Ex: Beechcraft 123, Washington ground, runway 27 taxi via C & D, hold short runway 33L
        iv. After taxi instructions are received, always read back:
            a. Runway assignment
            b. Any clearance to enter a specific runway
            c. Any instruction to hold short of a specific runway or line up and wait
                - Controllers are required to request readback of hold short instructions if not received
            d. Ex. Beechcraft 123, runway 27 taxi via C & D, hold short of runway 33L
                - Per the AIM example, in 4-3-18 d.1., you're not technically required to readback "taxi via C & D" but it helps catch errors and prevent incursions
        v. Example After Landing Radio Call
            a. "XXXX ground, Beechcraft 123, clearing runway 24R on taxiway P3, request clearance to ABC FBO"
            b. Ground: Beechcraft 123, XXXX ground, taxi to ABC FBO via taxiways P3, D, and B
            c. "Beechcraft 123, taxi to ABC FBO via P3, D and B"
    C. Uncontrolled Airports AI.V.D.K7b
        i. Planning
            a. Be familiar with the local procedures, runway use, traffic pattern direction and altitude
                - During calm wind conditions, flight operations may occur at more than one runway at the airport
            b. Be aware instrument approaches may be flown to runways other than the VFR runway in use
            c. Be alert, communicate intentions on the CTAF and listen for other aircraft
        ii. Communication
            a. Monitor/communicate on the CTAF from engine start, taxi, and until 10 miles from the airport
            b. Announce taxi intentions on the CTAF
        iii. Maintain situational awareness
            a. Always be aware of the route and know where you and other aircraft are
            b. Not all aircraft are radio-equipped; therefore, before entering or crossing a runway, scan the full length of the runway, including the final approach and departure paths

2. Plan, Brief, Review AI.V.D.K7a
    A. Route Planning
        i. Current References AI.V.D.K2
            a. Review the chart supplement & airport diagram
            b. Review Notices to Air Missions (NOTAMs) for taxiway closures, changes, inoperative lighting, etc.
        ii. Large airports often have pre-designated, or standard, taxi routes, review these for familiarity
            a. Used to reduce frequency congestion and streamline taxi procedures
        iii. Based on the runway in use and usable taxiways, review the expected routes, hot spots, etc.
    B. Taxi Brief
        i. Passenger brief, if not already completed
            a. SAFETY brief (FAASafety Passenger Briefing Card)
                - Described in V.B. Flight Deck Management
        ii. AC 91-73: Taxi operations briefings should include the following (prior to taxi, and prior to landing)
            a. Ground Procedures
                - Timing and execution of checklists/communications that will not interfere with taxiing
                - Expected route/any abnormalities or unusual procedures
                - Identify critical locations on the taxi route (hold short, hot spots, etc.)
                - Address previous experience/unusual procedures or techniques

        - During low visibility operations, brief the requirements and considerations
    b. Expectations of others (pilots of passengers) in the plane
        - Sterile flight deck procedures - encourage others to speak up if they see a potential conflict
        - Use of airport diagrams (pilots)
    c. Cell phones/electronic devices should be off
- C. Record & Review
    - i. Always write down ATC taxi instructions to prevent mistakes
        - a. Helps ensure you follow ATC's instruction, rather than what you expected or planned
    - ii. Review the route given by ATC, ask for help in case of confusion
        - a. Progressive Taxi
            - If unfamiliar with the airport or confusion exits, you can request progressive taxi instructions
            - Step-by-step routing directions
        - b. Be aware of hold short lines and ILS critical areas (if in use) on your route of taxi
            - Without explicit clearance, do not cross either of these (only required if ILS critical areas are in use)
    - iii. Benefits
        - a. Recording taxi instructions
            - Prevents mistakes and forgetfulness
            - RM: Combats confirmation/expectation bias AI.V.D.R2
                - a Expectation Bias: Your expectations can influence behavior
                    1. Ex: You always taxi C, D to runway 27, so when ground clears you a different route (A, F, D), out of habit/expectation you hear what you expect to hear (C, D) and taxi the wrong route
            - Verifies what you heard is what the controller said
        - b. Reviewing the taxi instructions & route
            - Increases situational awareness
            - Allows the pilot to resolve any confusion/questions prior to moving
            - Allows the pilot to operate with their head up/eyes outside to the max extent

3. RM: **Appropriate Flight Deck Activities** (RM: Activities & Distractions) AI.V.D.K7a, AI.V.D.R1
- A. For safety reasons the pilot's workload should be at a minimum during taxi operations
    - i. This can be accomplished through SOPs that direct attention only to essential tasks while taxiing
    - ii. Complete pre-taxi checklists and data entry *prior* to taxi
    - iii. All heads down activities should be done only when the aircraft is stopped
- B. A sterile flight deck should be implemented from taxi through climb to focus on taxiing/ATC instruction
    - i. Distractions are dangerous, remove them from view
        - a. If a person, explain the situation to them, and ask them to stop
- C. Taxiing Near Other Aircraft
    - i. Use a "continuous loop" process to monitor and update their progress and location
        - a. Know your present location and mentally calculate the next location that will require increased attention (crossing traffic, hot spot, etc.)
    - ii. Awareness is enhanced by understanding the clearance issued to pilots, other aircraft, and vehicles
        - a. Listen to other aircraft on the radio and the instruction they are given, develop a picture of other aircraft in relation to you, maintain situational awareness!
        - b. Don't set expectations, listen to, and comply with, the clearance(s) you receive
    - iii. Be especially vigilant if another aircraft with a similar call sign is on frequency
        - a. Care should be taken to avoid inadvertently executing a clearance for another aircraft
        - b. Ask if you're unsure of who the radio call was for

4. **Taxiing**
- A. Basics

i. Steering
   a. Accomplished with the rudder pedals and brakes
   b. To turn, apply rudder toward the desired turn and use power/brake to control the taxi speed
      - Add brake pressure to the brake on the inside of the turn to decrease turn radius
   c. Rudder should be held until just short of the point where the turn is to be stopped
ii. Speed
   a. Controlled 1st with power and 2nd with brake pressure (use the toe pedals to apply brakes)
      - Brakes should be applied smoothly and evenly
   b. Primary speed requirement is safe, and under positive control (be able to stop, turn when desired)
      - Taxi as though the brakes are inoperative – At the speed of a fast walk
      - Taxiing too fast can be dangerous – Ground loop, incursion, loss of control, etc.
   c. Don't ride the brakes
      - If too fast, allow the aircraft to accelerate, then brake to slow below a normal taxi, and repeat
      - Prevents overuse and excessive wear on the brakes
iii. Centerline
   a. *Keep the centerline between your outside leg and the stick
      - Adjust the sight picture as necessary if this sight picture does not work for you or the specific aircraft
iv. Stop with the nose wheel straight to prevent side loading and to make moving again easier

B. Taxi Checks
   i. Obtain taxi clearance and review and brief the route
   ii. Brake Check
      a. Test the brakes for proper operation as soon as the airplane is put in motion
      b. Gently apply power to start moving forward slowly, then retard the throttle and simultaneously apply just enough pressure to one side, then the other to confirm proper function/reaction
      c. If braking performance is unsatisfactory, the engine should be shut down immediately
   iii. Apply taxi basics and appropriate flight deck activities
   iv. Taxi Check
      a. While moving, verify proper instrument indications and operation
      b. Attitude Indicator - No more than 5° of pitch or bank indicated
      c. Turn and Slip Indicator - Wings move with the turn/Ball opposite the turn/Inclinometer is full of fluid
      d. Magnetic compass and heading indicator are moving toward known headings
         - Magnetic compass has no cracks, leaks, or bubbles

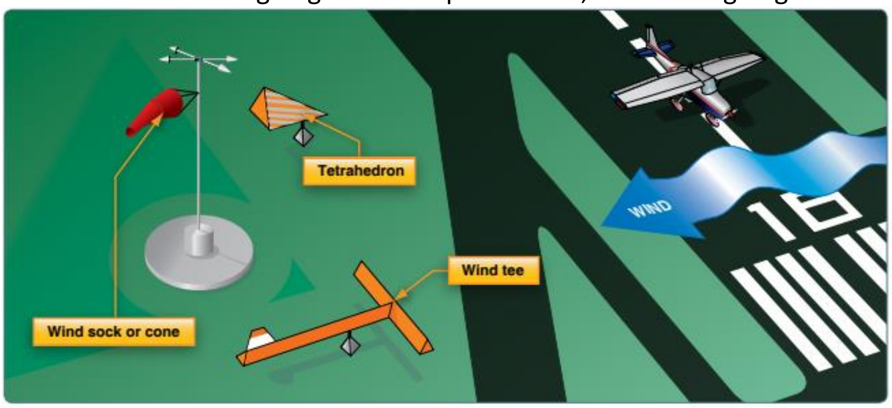
C. Aircraft Lighting AI.V.D.K6
   i. Engines Running: Turn on the rotating beacon whenever an engine is running
   ii. Taxiing: Prior to commencing taxi, turn on navigation, position, and anti-collision lights
      a. Turn on the taxi light when moving or intending to move on the ground
      b. Turn it off when stopped or yielding or as a consideration to other pilots or ground personnel
      c. Strobe lights should not be used during taxi if they will adversely affect the vision of others
   iii. Crossing a Runway: All exterior lights should be illuminated when crossing a runway
   iv. Entering the Departure Runway for Takeoff or Line Up and Wait: Pilots should make their aircraft more visible to aircraft on final and to ATC by turning on all lights, except for landing lights
      a. Strobe lights should not be illuminated if they will adversely affect the vision of other pilots
   v. Takeoff: Landing lights should be turned on when takeoff clearance is received, or when commencing takeoff roll at an airport without an operating control tower

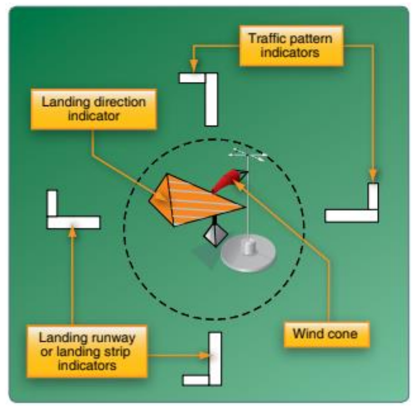
5. Wind Corrections AI.V.D.K5

A. Recognizing Wind Direction
   i. ATIS, ATC, FSS can provide wind direction

ii. Wind Indicators
   a. Windsock or Cone: Wind direction is opposite the direction the sock is pointing
      - Generally, each ring (orange/white) indicates a wind speed of 3 knots (max 15 knots)
      - Gusts can be recognized by the sock extending out and moving down
   b. Tetrahedron & Wind Tee: Move freely and align with the wind direction
      - May be manually positioned to align with the runway in use (instead of showing wind direction)
         a Verify with the windsock, if available
   c. Generally, located in a central location near the runway
      - May be placed in the center of a segmented circle, which identifies the pattern direction
   d. Wind blowing across water, tall grass, smokestacks, etc.

iii. Use the heading indicator/heading bug to visualize wind in relation to the airplane
   a. Heading bug: as the airplane turns, the heading bug moves with it



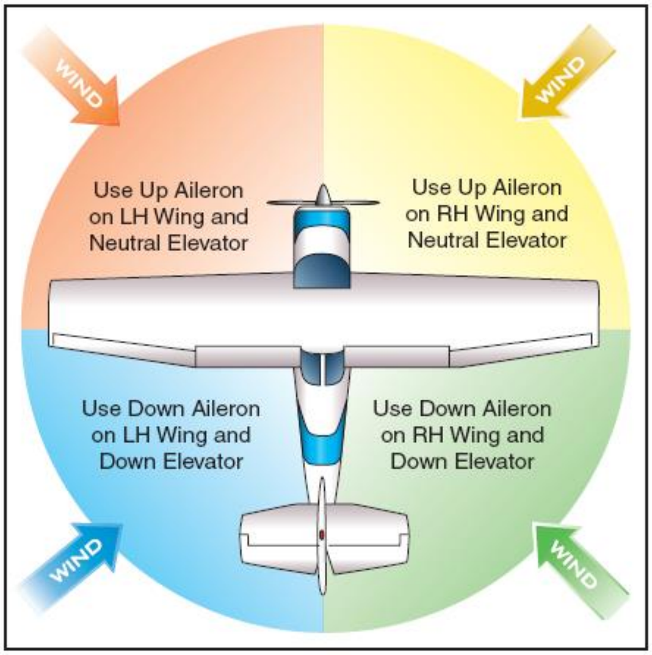


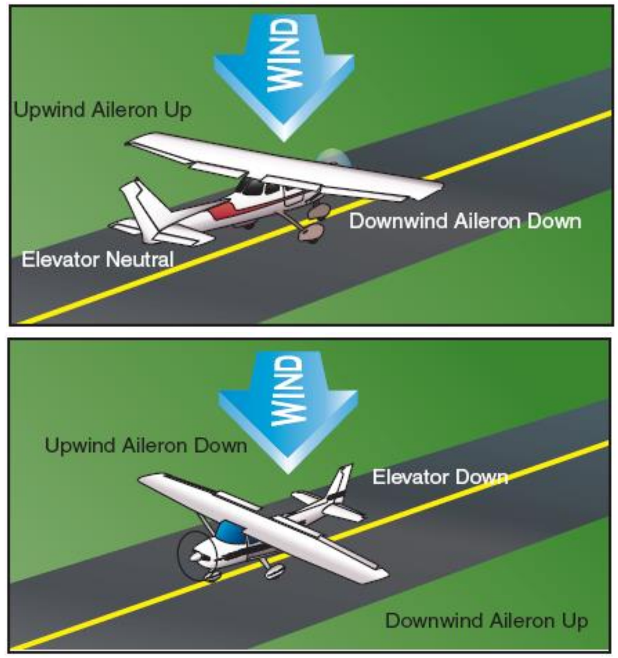
B. Downwind Taxiing
   i. Usually, will require less engine power after the initial ground roll is begun
   ii. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally

C. Taxiing with a quartering headwind
   i. Ailerons are turned into the wind and the elevator is held neutral
      a. To prevent the wind from lifting the upwind wing, aileron should be held into the wind
         - Upwind aileron is UP, reducing the effect of the lifting action
      b. The downwind aileron will be DOWN
         - A small amount of lift/drag is put on this wing keeping the upwind wing down

D. Taxiing with a Quartering Tailwind
   i. Flight controls are positioned to dive with the wind
      a. Ailerons are turned with the wind, and the elevator is DOWN
      b. The upwind aileron is DOWN in this case (opposite of a head wind)
      c. These control positions reduce the tendency of the wind to nose the plane over

E. These corrections help minimize weathervaning and make the airplane easier to steer





6. Night Operations AI.V.D.K7d

A. Aircraft lighting should be used as described above AI.V.D.K6

i. Additionally, at night when cleared to line up and wait. line up slightly (about 3') off the centerline to enable a landing aircraft to differentiate you from the runway lights

B. Be more cautious at night

i. Reduced visibility makes taxiing more difficult

a. Ensure you remain on the assigned route; it is easier to get confused and miss a turn at night

b. Taxi slower, allow yourself ample time to stop if something suddenly appears in front of you

- Not necessarily another airplane (animal, debris, FOD, etc.)

c. Look closely for taxiway markings (especially hold short lines)

- Some airports have lights in the ground along with hold short lines, some don't
- Use lights/lighted signs along taxiway edges to maintain position

7. Low Visibility AI.V.D.K7e

A. Taxi During Low Visibility (AIM 4-3-19)

i. Focus entire attention on the safe operation of the aircraft while it is moving

a. Taxi slowly

b. Focus should be outside

c. Sterile flight deck

d. Withold checklists and nonessential communication until stopped with the brakes set

ii. Notify the controller of difficulties or at the first indication of becoming disoriented

iii. Lack of visibility from the tower can prevent visual confirmation of adherence to taxi instructions

8. RM: Runway Incursions AI.V.D.R4

A. Taxi First

i. Eyes outside

ii. Maintain a sterile flight deck

iii. If a checklist needs to be completed, or attention needs to be diverted from taxiing, wait until stopped

iv. In the case of an emergency, stop the aircraft immediately and proceed as required

B. Maintain Situational Awareness

- i. Know where you are and where you're going – have a taxi diagram
- ii. Build a mental picture of other traffic on the airport
  - a. Listen to the ground/CTAF frequency and be alert to other traffic taxiing
- iii. Review NOTAMS prior to taxi for information on runway/taxiway closures and construction areas

C. Communication Matters
- i. Read back all runway/taxiway crossing and hold instructions using proper phraseology/good discipline
- ii. Write down complex instructions, especially at unfamiliar airports
  - a. Before taxiing, ask yourself whether the instructions make sense – Contact ground if they don't
  - b. Request progressive taxi, if necessary

D. Be Conservative
- i. Taxi at a safe speed (fast walk)
- ii. Apply the Right-of-Way rules (right-of-way is the same as in the air)

E. RM: Route and/or Runway Change AI.V.D.R3
- i. Ask for a safe place to stop, if necessary
- ii. Copy the new taxi instructions and review the route
- iii. Request progressive, if necessary

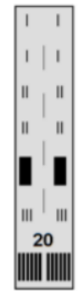
F. Entering/Crossing Runways AI.V.D.K7c
- i. Remember, a specific clearance is required to cross all runways
- ii. Hold lines indicate where an aircraft is supposed to stop when approaching a runway
  - a. Approaching from the dashed side, cross and stop fully passed the solid lines (no clearance necessary)
  - b. If approaching hold lines from the solid side, do not cross without a clearance
    - If you arrive at hold short lines without a clearance (or are unsure), stop and request clearance
    - Clarify confusion, never assume
  - c. Unauthorized crossing of hold lines could result in an incursion with an aircraft taking off or landing
    - At the high speeds associated with TO/LDG, incursions are much more hazardous
- iii. Actions
  - a. Prior to crossing the hold short lines, clear both directions (approach path & the runway surface)
  - b. Crossing a runway: Turn on all lights
  - c. Entering for departure: Turn on all lights, except turn on the landing light when cleared for takeoff

G. Landing and Rollout
- i. Brief the landing/rollout plan
  - a. Know where you will stop, what taxiways are appropriate to use/not use, and potential hot spots
  - b. Taxi slow, don't exit at high speeds
- ii. After landing, ensure that the entire aircraft, has crossed the landing runway's hold short line
  - a. If you can't clear the landing runway, stop and immediately advise ATC
- iii. If stopped between parallel runways, only cross when cleared to cross
  - a. Never cross the solid side of hold short lines without a clearance
- iv. Maintain a sterile flight deck

9. Airport Markings AI.V.D.K4

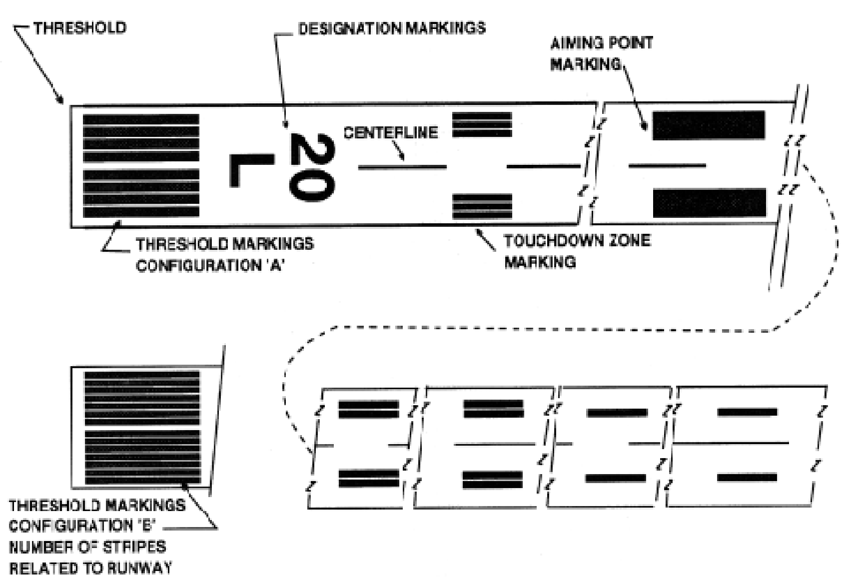
A. Runway Markings
- i. General
  - a. There are three types of markings for runways:
    - Visual; Nonprecision Instrument; Precision Instrument
- ii. Diagram Notes
  - a. Note 1: Required on runways serving category C & D aircraft, and for runways intended for international commercial air transport
  - b. Note 2: Required on 4,200' or longer runways serving categories C & D airplanes
  - c. Note 3: Required on 4,200' or longer instrumented runways

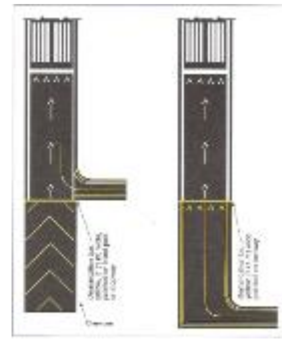
      d. Note 4: Used when the full runway pavement width may not be available for use as a runway
   iii. Runway Designators
      a. Purpose - To identify/differentiate runways from the approach end
         a The whole number to the nearest one-tenth of the magnetic azimuth of the runway
            1. To Magnetic North
         b Letters differentiate between left (L), right (R), and center (C) runways

Runway Surface Marking Scheme	Threshold Approach Category		
	Visual Approach	Non-precision Approach (Approaches with vertical guidance not lower than 0.75 statute mile visibility)	Precision Approach (Approaches with vertical guidance lower than 0.75 statute mile visibility)
Runway diagram			
Landing Designator	Required	Required	Required
Centerline	Required	Required	Required
Threshold	Note 1	Required	Required
Aiming Point	Note 2	Note 3	Required
Touchdown Zone	(not applicable)	(not applicable)	Required
Edge Markings	Note 4	Note 4	Required

      b. Markings - Large white numbers
   iv. Runway Centerline Marking
      a. Purpose - Identifies the center of the runway providing alignment guidance for takeoff and landing
      b. Markings - A line of uniformly spaced stripes and gaps
   v. Runway Aiming Point Markings
      a. Purpose - Serves as a visual aiming point for a landing aircraft
      b. Markings - Broad white stripe on each side of the centerline, approximately 1,000' from the threshold
   vi. Runway Touchdown Zone Markers
      a. Purpose - Identifies touchdown zone for landing operations and provide distance info in 500' increments
      b. Markings - Groups of 1, 2, and 3 rectangular bars in pairs about the runway centerline
   vii. Runway Side Stripe Markings

Precision Instrument Runway Markings





a. Purpose - Delineate the edges of the runway providing a contrast between the runway and shoulder
b. Markings - Continuous white stripes located on each side of the runway

viii. Runway Shoulder Markings
a. Purpose - May be used with side stripes to identify pavement areas not intended for aircraft use
b. Markings - Yellow stripes

ix. Runway Threshold Markings
a. Purpose - Identifies the beginning of the runway available for landing
b. Markings - 8 longitudinal stripes of uniform dimensions placed about the centerline
- The number of stripes is related to runway width

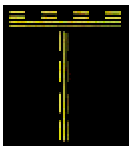
Runway Width	Stripes
60 feet	4
75 feet	6
100 feet	8
150 feet	12
200 feet	16

c. The threshold can be displaced or relocated
- Displaced Threshold (DT)
  a Explanation
  1. A threshold at a point on the runway other than the designated beginning of the runway
  2. Reduces the amount of runway available for landings
  3. Can be used for taxiing, takeoff, and landing rollout
     a. Cannot be used for landing on, only the landing rollout
  b Markings
  1. A 10' wide white threshold bar is located across the runway at the displaced threshold
  2. White arrow heads are located across the runway just prior to the threshold bar
  3. White arrows are down the centerline between the runway and displaced threshold
  4. Demarcation Line
     a. Purpose - Delineates the displaced threshold from a blast pad, stopway, or taxiway prior to the runway
     b. Markings - 3 feet wide and yellow
  5. Chevrons
     a. Purpose - Show areas aligned with the runway that are unusable for taxi, takeoff, and landing
     b. Markings - Yellow arrows
- Relocated Threshold
  a Explanation
  1. Sometimes construction or other activities require the threshold to be relocated
  2. A NOTAM should be issued identifying the portion of the runway is closed
     a. EX: 10/28 W 900 CLSD
  b Markings – Identification can vary, as the duration of the relocation varies
  1. Common practice is to use a 10' wide white threshold bar across the runway
  2. Runway lights between the old threshold and new threshold will not be illuminated
  3. Runway markings in this area may or may not be showing

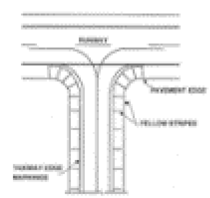
x. Blast pad/Stopway Area
a. The blast pad area is an area where a propeller or jet blast can dissipate without creating a hazard

b. Stopway is paved to provide space to decelerate/stop in the event of an aborted takeoff (chevrons)

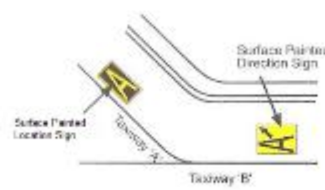
B. Taxiway Markings
  i. General
    a. Taxiways should have centerline/runway holding position markings whenever intersecting a runway
    b. Edge markings separate the taxiway from areas not for aircraft use or define taxiway edges
    c. May have shoulder/hold position markings for ILS critical areas and taxiways/taxiway intersections
  ii. Taxiway Centerline Markings
    a. Normal Centerline
      - Purpose - Provide a visual cue to permit taxiing along a designated path
        a Markings - A single continuous yellow line that is 6" - 12" wide
    b. Enhanced Centerline



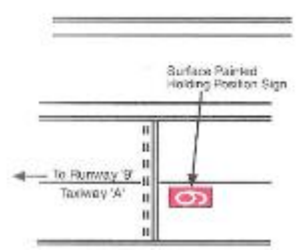
      - Purpose - Same as above but at larger commercial airports to warn that a runway hold position marking is being approached and unless cleared to cross, the aircraft should prepare to stop
      - Markings - A parallel line of yellow dashes on either side of the normal taxiway centerline
        a Centerlines are enhanced for a max of 150' prior to a runway holding position marking
  iii. Taxiway Edge Markings
    a. Purpose - Defines the edge of the taxiway (usually when edge doesn't match up with pavement)
    b. 2 types of markings, depending on whether the aircraft is supposed to cross the taxiway edge
      - Continuous Markings
        a Purpose - Define the taxiway edge from the shoulder/paved surface not for use by aircraft
        b Markings - Continuous double yellow line with each line at least 6'' wide and 6'' apart
      - Dashed Markings
        a Purpose - Define the taxiway edge when adjoining pavement is intended for aircraft (Apron)
        b Markings - Broken double yellow line (6" wide, spaced 6" apart; dashes are 15' long and 25' apart)



  iv. Taxi Shoulder Markings
    a. Purpose - Paved shoulders prevent erosion but they may not support aircraft
    b. Markings - Taxiway edge markings will usually define this area
      - If confusion exists to the side of use, yellow shoulder markings are used
  v. Surface Painted Taxiway Direction Signs
    a. Purpose - When it isn't possible to offer direction signs at intersections, or to supplement such signs
    b. Markings - Surface painted location signs with a yellow background and black inscription
      - Adjacent to the centerline with signs indicating left turns on the left side of the centerline and vice versa



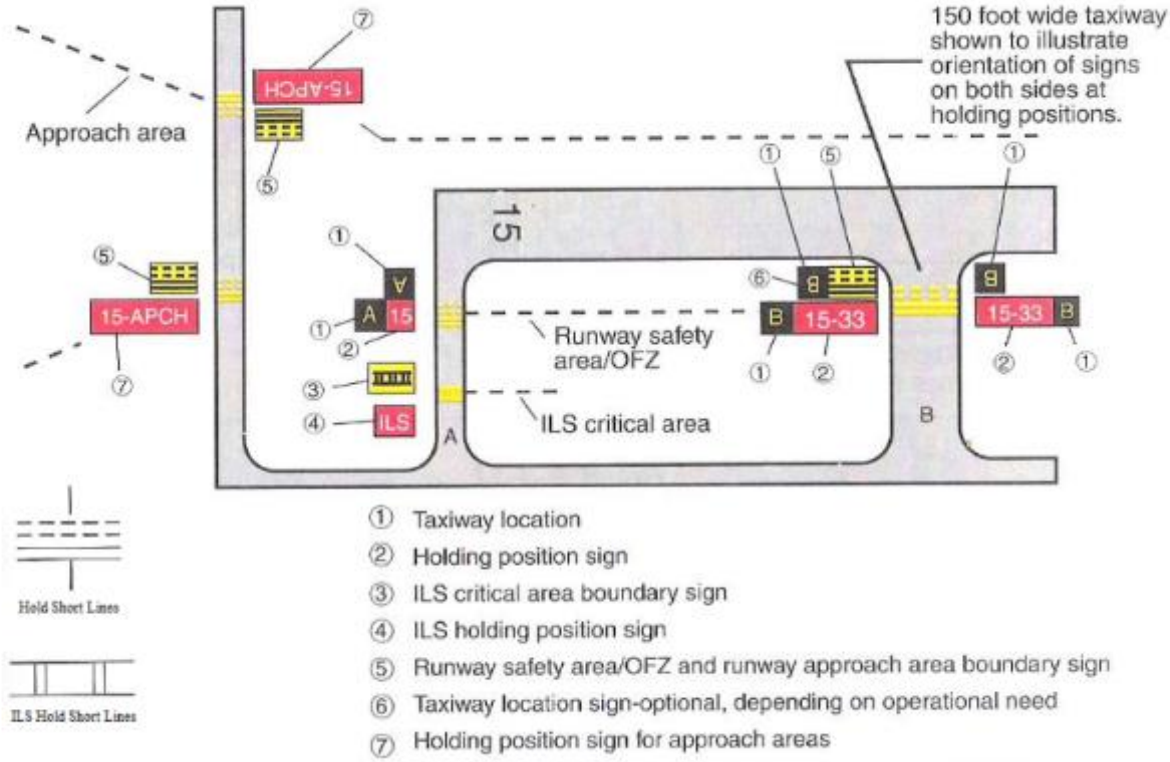
  vi. Surface Painted Location Signs
    a. Purpose - Supplement location signs alongside the taxiway assisting in confirming the taxiway one is on
    b. Markings - Black background with a yellow inscription, right of center



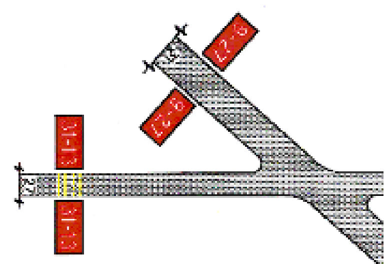
  vii. Geographic Position Markings
    a. Purpose - Identifies aircraft location during low visibility operations
    b. Markings - Left of the taxiway centerline in the direction of taxiing

      - A circle with an outer black ring, inner white ring and a pink circle
        a When on dark pavements the white/black ring are reversed
      - Designated with either a number or a number and a letter

a Number corresponds with consecutive position on the route



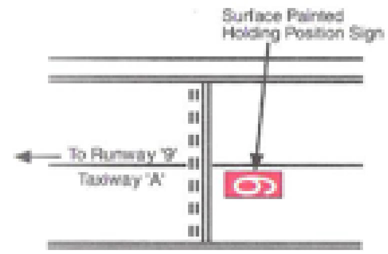
C. Holding Position Markings
   i. General
      a. Show where an aircraft is supposed to stop when approaching a runway (hold on the solid side)
      b. 4 yellow lines (2 Solid/2 Dashed) spaced 6" or 12" apart across the width of the taxiway or runway
         - 3 locations where runway hold lines are encountered: [1]Taxiways; [2]Runways; [3]Approach Areas
   ii. Runway Holding Position Markings on Taxiways
      a. Purpose - Identify where to stop without a clearance onto the runway
         - Always stop so that no part extends beyond the hold markers
         - Don't cross without clearance and separation at uncontrolled airports
   iii. Runway Holding Position Markings on Runways (as shown to the right)



      a. Purpose - Only installed if normally used for LAHSO or taxiing operations
         - Must stop before markings/exit prior to reaching the position
      b. Markings - Sign (white inscription/red background) next to hold markings
         - Markings are placed on the runway prior to the intersection
   iv. Taxiways Located in Runway Approach Area
      a. Purpose - Hold aircraft on a taxiway so it doesn't interfere with operations
      b. Holding Position Markings for Instrument Landing System (ILS)
         - Purpose - Hold aircraft when the ILS critical area is being protected
         - Markings - 2 yellow solid lines 2' apart joined by pairs of solid lines 10' apart across the taxiway
      c. Holding Position Markings for Taxiway/Taxiway Intersections
         - Purpose - Installed on taxiways where ATC normally holds aircraft short of a taxiway intersection
         - Markings - Single dashed line extending across the width of the taxiway

- a If requested to hold short of a taxiway without markings, provide adequate clearance from the taxiway

d. Surface Painted Holding Position Signs (as shown to the right)



- Purpose - Used to supplement the signs located at the holding position
  - a Normally used when the width of the holding position on the taxiway is greater than 200’
- Markings - Red background/white inscription, left of center, on the holding side, prior to hold lines

D. Other Markings

i. Vehicle Roadway Markings

a. Purpose - Used to define a path for vehicle operations on or crossing areas also intended for aircraft

b. Markings - White solid line delineates each edge and a dashed line separates lanes

- In lieu of the solid lines, zipper markings may be used to delineate edges

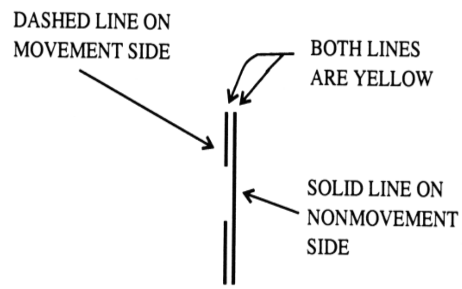
ii. VOR Receiver Checkpoint Markings

a. Purpose - Allow the pilot to check aircraft instruments with navigational aid signals

b. Markings - A painted circle with an arrow in the middle (arrow is aligned toward the facility)

- Located with a sign on the apron/taxiway
- Sign shows the VOR station ID letter, course for the check, and DME data (if necessary)
- Black letters/numerals on a yellow background

iii. Nonmovement Area Boundary Markings (as shown on the right)



a. Purpose - Delineates the movement area (The area under air traffic control)

b. Markings - 2 yellow lines (one solid and one dashed) 6” in width

- Solid line is the nonmovement area side, the dashed line is the movement area side

iv. Marking and Lighting of Permanently Closed Runways

a. Purpose - For runways and taxiways which are permanently closed

b. Markings - The lighting circuits will be disconnected

- The runway threshold, designation, and touchdown markings are obliterated
- Yellow crosses are placed at each end of the runway and at 1,000’ intervals

v. Temporarily Closed Runways and Taxiways

a. Purpose - To provide a visual indication to pilots that a runway is temporarily closed

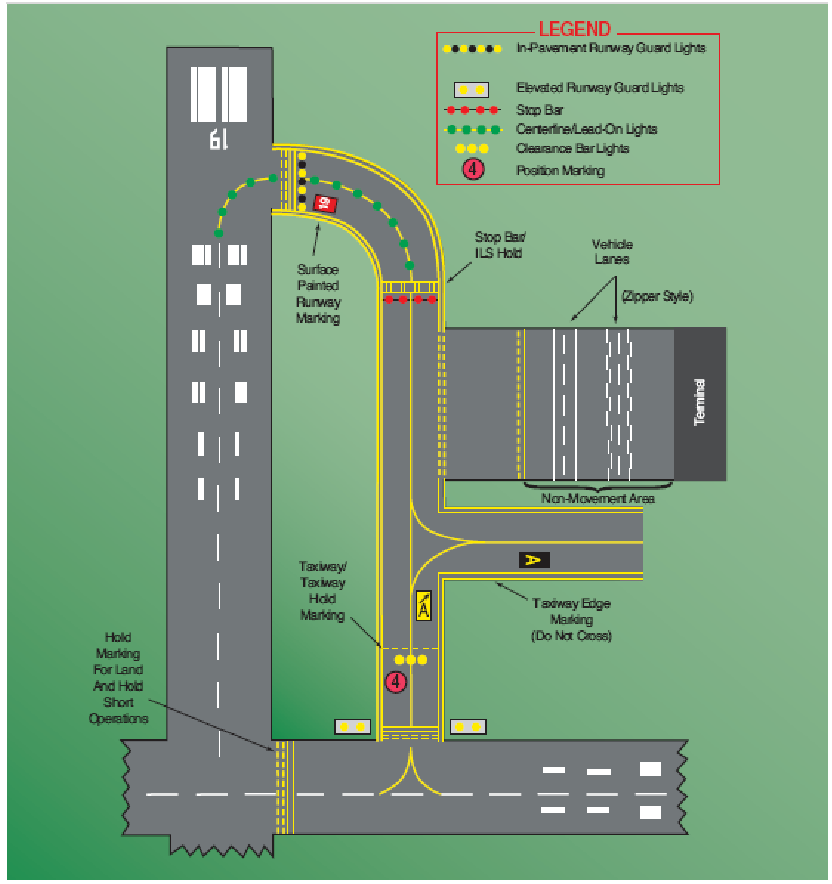
b. Markings - Yellow crosses are placed on the runway at each end

- A raised lighted yellow cross may be placed on each end of the runway instead
- A visual indication may not be present depending on the reason for closure, duration of the closure, configuration and the existence and hours of operation of an airport control tower
  - a Check NOTAMs and the ATIS for information
- Closed taxiways are treated as hazardous areas and blockaded; no part of the aircraft may enter
  - a As an alternative, a yellow cross may be installed at each entrance to the taxiway

10. Airport Signs

AI.V.D.K4

A. General

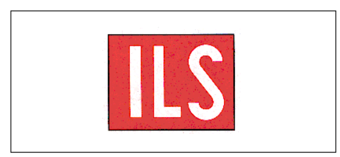


- i. Six types of signs installed on airfields
  - a. Mandatory Instruction; Location; Direction; Destination; Information; Runway Distance Remaining

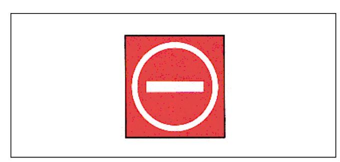
B. Mandatory Instruction Signs

- i. Purpose - Denote entrance to runway or critical area/area where aircraft are prohibited
- ii. Markings - Red background with a white inscription
- iii. Typical Mandatory Signs and Applications
  - a. Runway Holding Position Sign
    - Located at the hold position on taxiways intersecting runways/runways intersecting runways
    - The sign states the designation of the intersecting runway
  - b. Runway Approach Area Holding Position Sign
    - Used when necessary to hold aircraft on a taxiway in a runway approach/departure area so it doesn't interfere with runway ops

  - c. ILS Critical Area Holding Position Sign
    - ILS system is being used, and it's necessary to hold at a location other than the Hold Markers
    - The sign will have the inscription "ILS" and will be located adjacent to the holding position marking on the taxiway

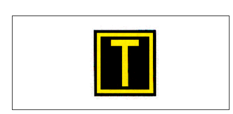


  - d. No Entry Sign
    - Prohibits an aircraft from entering an area
    - Typically, on a taxiway intended to operate in one direction or vehicle intersections that may be mistaken as a taxiway/movement surface

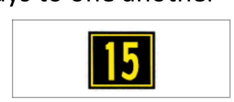


C. Location Signs

- i. Purpose - Identify either a taxiway or runway on which the aircraft is located
  - a. Other location signs provide a visual cue to assist in determining when an area has been exited
- ii. Taxiway Location Sign
  - a. Purpose - Along taxiways to indicate location
  - b. Markings - Black background with yellow inscription and border



- iii. Runway Location Sign
  - a. Purpose - Complement compass info; typically installed where the proximity of runways to one another could cause confusion as to which runway the pilot is on
  - b. Markings - Black background with a yellow inscription

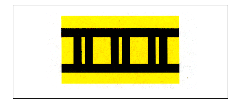


- iv. Runway Boundary Sign

a. Purpose - Provides a visual cue to use as a guide in deciding when “clear of the runway”
   - Adjacent to the hold markings on the pavement
   - Visible when exiting the runway

b. Markings - Yellow background/black inscription depicting the hold markings

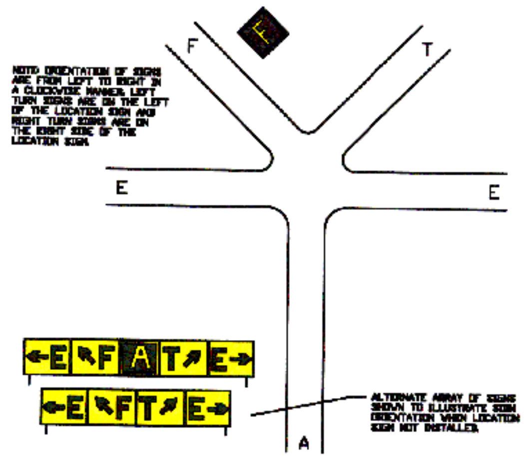
v. ILS Critical Area Boundary Sign
   a. Purpose - Provides a visual cue to use as a guide in deciding when clear of the ILS critical area
      - Adjacent to ILS hold markings and can be seen leaving the critical area



   b. Markings - Yellow background/black inscription depicting ILS hold markings

D. Direction Signs
   i. Purpose - Identify the designations of intersecting taxiways leading out of an intersection
      - Designations and their arrows are arranged clockwise from the 1st taxiway on the pilot’s left
   ii. Markings - Yellow background/black inscription with an arrow indicating the turn direction

E. Destination Signs
   i. Purpose - Indicates a destination on the airport
      a. Destinations commonly shown are
         - Runways
         - Aprons
         - Terminals
         - Military Areas
         - Civil Aviation Areas
         - Cargo Areas
         - International Areas
         - FBOs



   ii. Markings - Yellow background/black inscription indicating a destination on the airport
      a. Always have an arrow showing the direction of the taxiing route to that destination sign

F. Information Signs
   i. Purpose - Used to provide a pilot with information on things such as:
      a. Areas the tower can’t see, radio frequencies, and noise abatement procedures
   ii. Markings - Yellow Background with a black inscription

G. Runway Distance Remaining Signs
   i. Purpose - Used to inform the pilot the amount of distance remaining on the runway
      a. The number on the sign indicates the thousands of feet of landing runway remaining
   ii. Markings - Black background/white numeral inscription

H. CE: Failure to comply with airport, runway, taxiway sings and markings
   i. Make sure to know the meaning and purpose of all the signs and markings
      a. If unsure, stop and ask ATC for clarification
      b. Failure to comply could lead to a runway incursion, phone call to the FAA, and/or license revocation

11. Airport Lighting and Visual Aids AI.V.D.K4

A. Taxiway Lights
   i. Taxiway Edge Lights
      a. Purpose - Outline the edges of taxiways during periods of darkness or restricted visibility
      b. Configuration - Emit blue light
   ii. Taxiway Centerline Lights
      a. Purpose - Used to facilitate ground traffic under low visibility conditions
      b. Configuration - Steady burning green lights along the centerline
   iii. Clearance Bar Lights
      a. Purpose - Installed to increase the conspicuity of the holding position in low visibility conditions

        - May also be installed to indicate the location of an intersecting taxiway during darkness
      b. Configuration - Three in pavement steady burning yellow lights
   iv. Runway Guard Lights
      a. Purpose - Enhance the conspicuity of taxiway and runway intersections
      b. Configuration - Either a pair of elevated flashing yellow lights on either side of the taxiway, or a row of in pavement yellow lights across the entire taxiway, at the runway hold marking
   v. Stop Bar Lights
      a. Purpose - Confirm ATC clearances to enter/cross the active runway in low visibility conditions
      b. Configuration - Row of red, unidirectional, steady burning in pavement lights installed across the entire taxiway at the runway hold position, and elevated steady-burning red lights on each side
         - Following ATC clearance, the stop bar is turned off and the lead-on lights are turned on
      c. Cautions
         - Never cross a red illuminated stop bar even if you have received ATC clearance
         - If after crossing, the lead-on lights extinguish, hold position and contact ATC for instruction
   vi. Runway Guard Lights
      a. Pair of elevated flashing yellow lights on either side of the taxiway, or a row of in-pavement yellow lights across the entire taxiway at the runway holding position marking
      b. Installed at taxiway/runway intersections
      c. Enhance conspicuity of taxiway/runway intersections

B. Runway Lighting
   i. Runway End Identifier Lights (REIL)
      a. General - Installed to provide rapid/positive identification of the approach end of a runway
      b. Configuration - A pair of synchronized flashing lights located on each side of the runway threshold
      c. Effective for:
         - Identification of a runway surrounded by a preponderance of other lighting
         - Identification of a runway which lacks contrast with the surrounding terrain
         - Identification of a runway during reduced visibility
   ii. Runway Edge Light Systems (HIRL, MIRL, LIRL)
      a. General - Outline the edges of runways during periods of darkness or restricted visibility conditions
         - Classified according to the intensity or brightness they are capable of producing
            a High Intensity (HIRL); Medium Intensity (MIRL); Low Intensity (LIRL)
               1. HIRL and MIRL have variable intensity controls
      b. Configuration
         - Runway edge lights - White
            a Instrument runways - Turn yellow the last 2,000,' or half the runway, whichever is shorter
         - Lights marking the end of the runway - Red/Green
            a Red is emitted toward the runway to indicate the end of the runway to a departing aircraft
            b Green is emitted outward from the runway end to indicate the threshold to landing aircraft
   iii. Runway Centerline Lighting System (RCLS)
      a. General - Installed on some precision runways to facilitate landing under adverse conditions
      b. Configuration
         - Located along the runway centerline and are spaced at 50' intervals
         - From the landing threshold, the lights are white until the last 3,000' of the runway
            a White lights begin to alternate with red for 2,000', and the last 1,000' all lights are red
   iv. Touchdown Zone Lights (TDZL)
      a. General - On some precision runways to indicate the touchdown zone in adverse visibility
      b. Configuration

- Two rows of transverse light bars disposed symmetrically about the runway centerline
- Steady burning white lights starting 100' beyond the landing threshold and extending to 3,000' beyond the landing threshold or to the midpoint of the runway, whichever is less

v. Taxiway Centerline Lead-Off Lights
   a. General
      - Provide visual guidance to persons exiting the runway
      - Color coded to warn: In runway environment/ILS critical area, whichever is more restrictive
   b. Configuration
      - Alternate green/yellow lights are installed, beginning with green, from the runway centerline to 1 light position beyond the runway hold position/ILS critical area hold position

vi. Taxiway Centerline Lead-on Lights
   a. General
      - Provide visual guidance to persons entering the runway
      - Warn: In the runway environment/ILS critical area, whichever is more conservative
   b. Configuration
      - Color coded with the same pattern as lead-off lights
      - Bidirectional (i.e., 1 side emits light for the lead-on function the other for the lead-off)

vii. Land and Hold Short Lights
   a. General
      - Used to indicate the hold short point on certain runways which are approved for LAHSO
         a Where installed, the lights will be on anytime LAHSO is in effect and off when not
   b. Configuration - A row of pulsing white lights installed across the runway at the hold short point

C. Control of Lighting Systems
   i. Operation of approach light systems and runway lighting is controlled by the control tower/FSS
      a. Pilots may request the lights be turned on or off
   D. Pilot Control of Airport Lighting (AIM 2-1-8)
      i. Radio control of lighting is available at some airports by keying the aircraft's microphone
         a. Often at airports without specified hours for lighting, airports with no tower/FSS, or when closed
      ii. All radio-controlled lighting systems at an airport operate on the same frequency
         a. CTAF is used to activate the lights at most airports, but other frequencies may also be used
            - Frequency is in Chart Supplement and standard instrument approach procedures publications
            - Frequency is not on sectional charts
      iii. Lights operate for 15 minutes

Key Mike	Function
7 times within 5 seconds	Highest intensity available
5 times within 5 seconds	Medium or lower intensity (Lower REIL or REIL-off)
3 times within 5 seconds	Lowest intensity available (Lower REIL or REIL-off)

D. CE: Failure to comply with airport, runway, and taxiway lighting

AI.V.D.K1 – Just about every section is applicable to Elements of Safe Taxi Operations

Conclusion:
Brief review of the main points
Requirements for safe taxiing include positive control of the aircraft, the ability to recognize potential hazards in time to avoid them, and the ability to stop or turn where and when desired without undue reliance on the brakes. Also, be aware of other traffic and its movement, write down and read back all clearances, and maintain the proper crosswind correction.

V.F. Before Takeoff Check

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of the elements related to the before takeoff check, and perform the check as required in the manufacturer's POH and as required in the ACS.
Key Elements	1. Read and Do 2. Departure Brief 3. Incursions and Hazards
Elements	1. Engine Warm Up 2. Positioning the Aircraft 3. Division of Attention 4. Checklist 5. Go/No Go Decision 6. Departure Brief 7. Before Entering the Runway 8. Avoiding Incursions 9. Runway Change
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the elements involved in a proper, thorough, and safe before takeoff check. The learner can make a competent decision as to whether the airplane is safe to fly and is vigilant in maintaining hazard and incursion avoidance.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Which situation would you rather be in? Discovering there is a problem with the airplane after takeoff and having to make an emergency landing or discovering there is a problem with the airplane before taxiing onto the runway?

Overview

Review Objectives and Elements/Key ideas

What

The before takeoff check is the systematic procedure for checking the engine, controls, systems, instruments, and avionics prior to flight.

Why

This final check ensures the airplane is ready for safe flight *before* taking off.

How:

1. **Engine Warm Up**
   A. Before takeoff check is usually performed after taxiing to a position near the runway (usually a run-up area)
      i. Allows time to reach minimum operating temperatures ensuring lubrication and internal engine clearances
         a. Better for the engine and provides more reliable indications
         b. *The oil temperature must reach a minimum value (DA20 - 75º)
   B. Scan all the engine instruments periodically to ensure they are suitable for the run-up and takeoff
2. **Positioning the Aircraft**
   A. A suitable location should be firm (smooth, paved or turf surface if possible) and free of debris
      i. Debris can be thrown backward potentially damaging the propeller and tail
   B. There should not be anything behind the aircraft that might be damaged by the airflow
   C. Recommended to point the airplane as closely as possible into the wind to minimize overheating
      i. Prolonged ground operations may cause cylinder head overheating long before there is an indication of rising oil temperature – considerably less airflow on the ground vs in-flight
      ii. Sometimes this is not possible due to the run-up area configuration or other aircraft, adjust as necessary
   D. After positioning, allow the aircraft to move forward slightly to straighten the nose wheel
      i. Considerable stress is placed on the nose wheel during the run-up
3. RM: **Division of Attention** AI.V.F.R1
   A. Attention must be divided inside and outside the aircraft
      i. If the brake slips, or if the toe brakes are not adequate, the airplane could move forward unnoticed
   B. Excessive time with your head down (checklists, etc.) can result in unmonitored movement
      i. This can be hazardous to yourself and others
   C. A good practice is to swap between one item inside to a look outside
4. **Checklist** AI.V.F.K1a. AI.V.F.K1b, AI.V.F.K1c
   A. Prepares the aircraft for takeoff and checks critical flight equipment and systems
   B. The before takeoff checklist provided by the manufacturer should be used to ensure a proper check
      i. Each airplane has different features and equipment
   C. Ensure each item of the checklist is completed (read and do)
      i. Never go solely off memory. It’s very easy to unintentionally miss something
   D. Review the Before Takeoff Checklist with the learner

    i. Discuss reasons for checking each item and how to detect errors
        a. Use the checklist and standards/requirements in the POH to make a Go/No Go decision

5. Go/No Go Decision

A. The PIC is responsible for determining whether the airplane is in a condition for safe flight
    i. Use the criteria set forth in the POH, as well as pilot judgement, to measure the airplane's performance
        a. Do not accept "close enough"
        b. If something is in limits but doesn't seem right (strange noise, etc.), have it checked before flying

B. This is your chance to catch a problem while safely on the ground rather than in flight
    i. If there is a problem, ask yourself, Are we still legal? Can the problem be recovered? Is this safe?
        a. Even if it's legal, and acceptable to fly, is it still safe?

C. If there are any doubts, return to the ramp for further investigation

6. RM: Departure Brief (RM: Potential engine failure or malfunctions, considering operational factors) AI.V.D.R4

A. Always have a plan before starting the takeoff roll. Brief that plan

B. Sample Structure
    i. Prior to rotate speed, plan to keep the aircraft on the ground (assuming the runway length allows this)
    ii. From rotation to a certain point (runway length allowing) you may be able to land on the remaining runway in the case of an engine failure. After this point, it will be unfeasible to land on the runway.
        a. Use the distance remaining signs along the runway edges to know when it is too late to return
    iii. Brief an altitude at and above which, you will turn around to return to the airport for landing
    iv. Between the point at which you can no longer land on the remaining runway (a) and the point you have the altitude to return to the airport (b) you will have to land on the most suitable surface outside of the airport

C. Before takeoff, review the performance speeds, expected takeoff distance and emergency procedures
    i. *V_R (44 knots), V_X (58 knots), V_Y (65 knots) - Announce the speeds
    ii. "Takeoff on runway 27, we have 5,500' of runway, performance shows we need 1,300' today"
        a. Ensure performance works with the runway, and conditions have not changed to prevent that
    iii. *Emergency
        a. Lose engine on the roll, close the throttle, and maintain control with the rudder/brakes
        b. Lose engine after rotation, with runway available, land on the remaining runway
        c. Lose engine above 600' AGL (DA20) attempt to turn back to the runway, otherwise land straight ahead

7. Before Entering the Runway

A. Visually check the area to ensure it is clear of anything that could be a hazard
    i. Airplanes, cars, animals, etc.

B. Check the runway, as well as final approach
    i. Remember, radio communication is not required at uncontrolled airports, be alert to aircraft in the pattern

C. RM: Consider Wake Turbulence AI.V.D.R3
    i. Departing after a Large Aircraft
        a. On the same runway
            - Rotate prior to their rotation point and climb above their climb path until turning clear
        b. Executing a low approach, missed approach, or touch-and-go
            - Wait at least 2 minutes prior to a landing or takeoff
            - Vortex hazard may exist along the runway/in the flight path, particularly in a quartering tailwind
    ii. Intersection takeoffs on the same runway
        a. Be alert to adjacent large aircraft operations, particularly upwind of the runway of intended use
        b. Avoid headings that cross below the larger aircraft's path
    iii. For more details, see lesson VII. RM Concepts – Wake Turbulence

8. Avoiding Incursions

A. Before moving, clear to the left, right and center

B. Just like when taxiing, know where other aircraft are in relation to you

        i. The pilot always has the responsibility to see and avoid
    C. Monitor the appropriate frequency (CTAF/Ground/Tower)
    D. Repeat all clearances, and do not cross hold short lines without a clearance to do so
    E. If any doubt exists, stop, and clarify
    F. Clear final approach before taxiing into the takeoff position
    G. Be safe and don't put yourself in a dangerous position

9. RM: **Runway Change** AI.V.D.R2

    A. Don't rush
        i. If already stopped in a safe place, consider remaining there until swapped to the new runway
    B. Performance
        i. Adjust for changes in runway length, wind direction, runway gradient, terrain, procedures, etc.
        ii. Ensure adequate performance and safety
        iii. Update any navigation equipment (GPS, VOR, etc.)
    C. Departure Brief
        i. Note differences and brief the departure for the new runway
    D. Taxi Instructions
        i. Review the taxi diagram
        ii. Request and readback taxi instructions
        iii. Confirm the route and begin the taxi

Conclusion:

Brief review of the main points

The before takeoff check is essential to ensure there are no problems before taking off. It is extremely important to use the correct checklist and make a safe decision regarding whether to make the flight. During this check, runway incursion and hazard avoidance is extremely important and should not be ignored.

AIRPORT OPERATIONS

VI.A. Communications, Light Signals & Runway Lighting Systems

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM

Objectives	The learner should develop knowledge of the elements related to radio communications and ATC light signals as described in the ACS.
Key Elements	1. Understanding 2. Who, Where, What 3. Plan Ahead
Elements	1. Radio Communication Procedures & Phraseology 2. ATC Clearance & Instructions 3. Selection and Use of Appropriate Frequencies 4. Radar Assistance 5. Transponders 6. Lost Communication 7. Runway Status Lights 8. Common Errors
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can properly use the radios throughout the flight. The learner understands proper procedures, phraseology, clearances, and light signals.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Everyone wants to sound like a real, professional pilot. This lesson will explain how we do that, while making you into a more professional pilot.

Overview

Review Objectives and Elements/Key ideas

What

Radio communication is the communication between the pilot and different ATC controllers throughout the phases of a flight. Light gun signals provide a means of communicating with the airplane in case radio communication becomes unavailable.

Why

Operating in and out of a controlled airport, as well as in a good portion of the airspace system, requires an aircraft to have two-way radio communications. For this reason, a pilot should be knowledgeable of radio procedures. Radio communications is a critical link in the ATC system. Understanding proper radio communication procedures strengthens the link and makes flying safer for everyone.

How:

1. **Radio Communication Procedures & Phraseology** AI.VI.A.K2, AI.VI.A.R1
   A. Understanding is the single most important thought in pilot-controller communications
      i. It is essential that pilots acknowledge each radio call with ATC with the appropriate aircraft call sign
      ii. Brevity is important, but, if necessary, use whatever words will get your message across
         a. Know what you're going to say before you say it
      iii. Good phraseology enhances safety and is the mark of a professional pilot
         a. The Pilot/Controller Glossary (link to the Glossary is under Publications) is very helpful in learning what certain words/phrases mean
   B. RM: Radio Technique (RM: Communication)
      i. LISTEN before you transmit
      ii. THINK before transmitting - Know what you want to say before you say it (write it down if needed)
      iii. After transmitting, wait a few seconds before calling again (The controller may be busy)
      iv. Be alert to the sound/lack of sounds in the receiver
         a. Check your volume, frequency, and make sure the microphone isn't stuck on transmit
      v. Be sure you are within the performance range of your equipment and the ground station equipment
         a. Remember higher altitudes increase the range of VHF "line of sight" communications
   C. Radio calls can be broken down into Who, Where, What:
      i. Who you are calling (Chicago Center)
      ii. Who you are (Diamond 4TS)
      iii. Where you are (10 miles South of _____)
      iv. What you want (Request flight following, or whatever you want)
   D. Non-towered Airport Communication
      i. Radio calls at non-towered airports can be broken down into a similar format:
         a. Who you are

- n-number

b. Where you are
   - Distance and direction from the airport (ex. 10 nm W), where you are parked (ex. _____ FBO), location on the airport (ex. intersection of taxiway B & F)

c. What you're doing (instead of what you want)
   - Ex: To enter left traffic for runway 25; to taxi to runway 31 via F, E; etc.

2. ATC Clearances and Instructions

A. An ATC clearance is an authorization by ATC to proceed under specified conditions within controlled airspace
   i. Not authorization to deviate from rules/regulations/min altitude or to conduct unsafe aircraft operation

B. When given a clearance:
   i. Record the clearance, if able
      a. This helps the read back, as well as any second guessing that may occur after the instruction
   ii. Read back the clearance
      a. Always read back the following:
         - Taxi instructions (AIM 4-3-18-9)
            a The runway assignment
            b Any clearance to enter a specific runway
            c Any instruction to hold short of a specific runway or line up and wait
               1. Controllers are required to request a readback of any hold short instructions if not received from the pilot
         - ATC clearances/instructions with altitude assignments, vectors, or runway assignments (AIM 4-4-7)
            a Reading back the "numbers" double checks understanding and reduces errors
         - All land and hold short operation (LAHSO) clearances (AIM 4-3-11-7)
            a The pilot can accept or reject ("unable") any LAHSO clearance. If accepted, always read it back
      b. Include the aircraft identification in all readbacks and acknowledgements
         - Ensures the correct aircraft received the clearance or instruction
         - More important the more congested the radios become and with aircraft with similar call signs
      c. Read back altitudes, restrictions, and vectors in the same sequence they're given
      d. When advised to change frequencies, acknowledge the instruction and change ASAP
      e. The pilot is expected to use the appropriate aircraft call sign to acknowledge all ATC clearances, frequency changes, or advisory information (AIM 4-4-1(b))
      f. If uncertain of a clearance, immediately request clarification from ATC (FAR 91.123)
         - Ask the controller to repeat ("say again")
         - Never assume you're right, if you're unsure just ask

C. It is the responsibility of the pilot to accept or refuse any clearance issued (AIM 4-4-1(b))
   i. FAR 91.3(a): The PIC is directly responsible for, and is the final authority as to, the operation of the aircraft
      a. If ATC issues a clearance that would cause a pilot to deviate from a rule or regulation, or would place the aircraft in jeopardy, it is the pilot's responsibility to request an amended clearance
      b. If a pilot prefers to follow a different course of action than what is in the clearance, the pilot is expected to inform ATC (you are making a request, not telling the controller what you will do)
         - When the pilot requests a different course of action, the pilot is expected to cooperate to prevent the disruption of traffic flow or creation of conflicting patterns

D. FAR 91.123: When an ATC clearance has been obtained, no pilot in command may deviate from that clearance unless an amended clearance is obtained, an emergency exists, or the deviation is in response to a traffic alert and collision avoidance system resolution advisory
   i. Except in an emergency, no person may operate an aircraft contrary to an ATC instruction in an area in which air traffic control is exercised

   ii. Each PIC who, in an emergency, or in response to a traffic alert and collision avoidance system resolution advisory, deviates from an ATC clearance or instruction shall notify ATC of that deviation as soon as possible
   iii. Each PIC who (though not deviating from a rule) is given priority by ATC in an emergency, shall submit a detailed report of that emergency within 48 hours to the manager of that ATC facility, if requested by ATC
   iv. Unless otherwise authorized by ATC, no person operating an aircraft may operate it according to any clearance or instruction issued to the pilot of another aircraft for radar air traffic control purposes
E. RM: Declaring Emergencies (AIM 6-1-2 Emergency Condition) AI.VI.A.R2
   i. An emergency can either be a distress or urgency condition
      a. Distress: Condition of being threatened by serious and/or imminent danger and of requiring immediate assistance
      b. Urgency: A condition of being concerned about safety and of requiring timely but not immediate assistance; a potential distress condition
   ii. Do not hesitate to declare an emergency when faced with distress conditions
      a. Ex: fire, mechanical failure, structural damage
   iii. An aircraft is at least in an urgency condition the moment the pilot becomes doubtful about position, fuel endurance, weather, or any other condition that could adversely affect flight safety
      a. This is the time to ask for help, not after it develops into a distress situation
   iv. Request assistance immediately if apprehensive for your safety for any reason
      a. Delay has caused accidents and cost lives

3. Selection and Use of Appropriate Frequencies AI.VI.A.K1

A. Preflight Planning
   i. Look up the primary frequencies you plan to use on the flight
      a. Tower, ground, ATIS, clearance delivery, and any other applicable frequencies at the departure, and arrival airport, as well as any divert airports you may use
         - The busiest portions of the flight (departure, arrival, and diverting) are stressful enough. Plan ahead to save yourself some time and work
      b. This information can be found in the Chart Supplement, Sectional Charts, ForeFlight, etc.
      c. The majority of ground control frequencies are in the 121.6 to 121.9 bandwidth
         - Ground is almost always 121 point something
         - If told to contact ground on .9, .8, .4, etc. that means 121.9, 121.8, 121.4, etc.
   ii. Keep this information easily accessible
      a. Most flight plans/nav logs have a designated space for frequencies
      b. Preferably organize the frequencies in the order you will use them
B. In the case a frequency needs to be found in flight, use available resources
   i. Turn on the autopilot
   ii. Keep the flight deck organized to quickly find the information you need
   iii. Ask ATC, if appropriate
   iv. Remember to fly the airplane first, then handle the radios and other duties
C. The Chart Supplement contains pertinent frequencies within/around the airport(s) you are operating in
   i. Weather, Tower/CTAF, Clearance Delivery, Ground, Unicom, Navaids, FSS, Approach/Departure
D. Airport Diagram contains airport specific frequencies
   i. Should be on hand in the airplane and easy to access
E. Charts provide frequencies as you navigate
   i. Communications Boxes (FSS)
   ii. Airport data provides tower/CTAF, Unicom, weather frequencies (ASOS, AWOS, or ATIS)
   iii. VOR frequencies are shown in blue outlined boxes
      a. ASOS/AWOS are available on some VORs
   iv. Class B, C, TRSA, and some radar approach frequencies are provided on sectional and terminal charts

- F. Once in contact with controllers, frequencies will be provided to reach further controllers
  - i. For example, while using flight following
- G. Use of improper frequencies
  - i. Understand each frequency's purpose (tower, ground, clearance, etc.)
    - a. Know who you need to call
    - b. Can vary between airports, for example at some airports ground handles flight following requests, and at others clearance delivery does
  - ii. If you get no response on the frequency
    - a. Wait a moment, the controller may be busy, then try again
    - b. Double check the frequency
    - c. If you were passed from one controller to another (ex. flight following), return to the last controller and ask them to repeat the frequency

4. Radar Assistance AI.VI.A.K7

- A. Radar equipped ATC facilities provide radar assistance to IFR aircraft & VFR aircraft, by request (flight following)
- B. Includes safety alerts, traffic advisories, limited vectoring when requested, and sequencing at some locations
  - i. Traffic advisories are issued based on controller radar targets and referenced in terms of the 12-hour clock
    - a. Provide distance in nautical miles, direction the target is moving, and aircraft type/altitude, if available
    - b. Traffic direction is based on aircraft track, therefore wind correction can affect clock position
- C. TRSA (Terminal Radar Service Area) exists at certain terminal locations
  - i. Provides separation between all participating VFR aircraft and all IFR aircraft
  - ii. Depicted on sectional charts and listed in the Chart Supplement
- D. Class B & C Airspace
  - i. Class C provides separation between IFR & VFR traffic and traffic sequencing
  - ii. Class B provides separation based on IFR, VFR, and/or weight and sequencing VFR arrivals to airports
- E. Radar Assistance does not relieve the pilot of the responsibility to see and avoid other aircraft

5. Transponders AI.VI.A.K4

- A. Provides aircraft information to Air Traffic Control and other aircraft
- B. Transponder Codes
  - i. When using flight following/radar assistance ATC assigns you a unique transponder code
    - a. Four numbers from 0-7 (4,096 possible codes)
    - b. When combined with radar returns, ATC can see the aircraft on their scope with the transponder info
  - ii. Standard Codes: VFR: 1200; Hijack: 7500; Lost Communication: 7600; Emergency: 7700
- C. Different types/modes of transponders broadcast different information
  - i. Mode A: Transmits 4-digit code that identifies an aircraft and its position
  - ii. Mode C: Mode A + ATC can see the aircraft's altitude
  - iii. Mode S: Transmits a variety of information to ATC & other aircraft
    - a. Unique ICAO address (assigned to each aircraft)
    - b. Heading, speed, other flight related data
    - c. Integral to TCAS (Traffic Collision Avoidance System) and ADS-B

6. Lost Communication AI.VI.A.K3, AI.VI.A.K6

- A. Light Gun Signals and their Meaning (AIM 4-3-13)

i. In the case of a loss of radio communication, the tower can communicate through light signals:

Color and Type of Signal	Movement of Vehicles, Equipment and Personnel	Aircraft on the Ground	Aircraft in Flight
Steady green	Cleared to cross, proceed or go	Cleared for takeoff	Cleared to land
Flashing green	Not applicable	Cleared for taxi	Return for landing (to be followed by steady green at the proper time)
Steady red	Stop	Stop	Give way to other aircraft and continue circling
Flashing red	Clear the taxiway/runway	Taxi clear of the runway in use	Airport unsafe, do not land
Flashing white	Return to starting point on airport	Return to starting point on airport	Not applicable
Alternating red and green	Exercise extreme caution!!!!	Exercise extreme caution!!!!	Exercise extreme caution!!!!

ii. General Information (AIM 6-4-2, AIM 4-3-13)
   a. Squawk 7600 to indicate a loss of two-way radio capability
   b. During daylight hours, acknowledge tower transmissions or light signals by moving the ailerons or rudder (rocking the wings)
   c. At night, acknowledge by blinking the landing or navigation lights
   d. Between sunset and sunrise, to attract the attention of the tower, turn on a landing light and taxi the aircraft into a position, clear of the active runway, so that the light is visible to the tower
      - The landing light should remain on until appropriate signals are received from the tower

iii. Disadvantages of Light Signals (AIM 4-3-13)
   a. Pilots may not be looking at the control tower at the time a signal is directed toward their aircraft
   b. Directions are limited since only approval/disapproval of a pilot's anticipated actions can be transmitted
      - No explanatory or supplemental information may be transmitted

B. Lost Communication Procedures
   i. Airborne Aircraft
      a. Receiver Inoperative - Receiving no audio on tower/ATIS frequencies
         - Remain outside or above Class D airspace until the direction and flow of traffic is determined
         - Advise tower of the aircraft type, position, altitude, and intention to land
            a Inform them of the radio failure
         - Enter the pattern, report position as appropriate, and watch for light gun signals from the tower
            a Acknowledge the signals as appropriate
      b. Transmitter Inoperative - Receive no response to calls, but can receive calls
         - Follow the previous procedures and monitor the appropriate radio frequency
            a Remain outside of the airspace until the direction and flow of traffic is determined
            b Enter the pattern, clearing aggressively, and watch for light gun signals
         - If you can hear ATC, they may ask you to acknowledge their radio calls with an ident
            a In this case light gun signals may not be necessary
            b Otherwise, acknowledge by rocking the wings/flashing the landing or navigation lights
         - Make all normal radio calls, just in case
      c. Receiver and Transmitter Inoperative
         - Follow the previous procedures
            a Remain outside of the airspace until the direction and flow of traffic is determined
            b Enter the pattern, clearing aggressively, and watch for light gun signals
            c Acknowledge the signals as appropriate
   ii. Trouble Shoot the Situation

a. Check the connections, your equipment, the receiver/transmitter, verify the volume is up, try different frequencies, is there an annunciation showing when you are transmitting (is it working?), etc.
    - Think outside the box

iii. In any of these situations it may be a prudent to land at a non-towered airport with lower traffic volume
    a. No radio communication is necessary
    b. Always be extra vigilant when not using the radio as other aircraft may be expecting standard radio calls

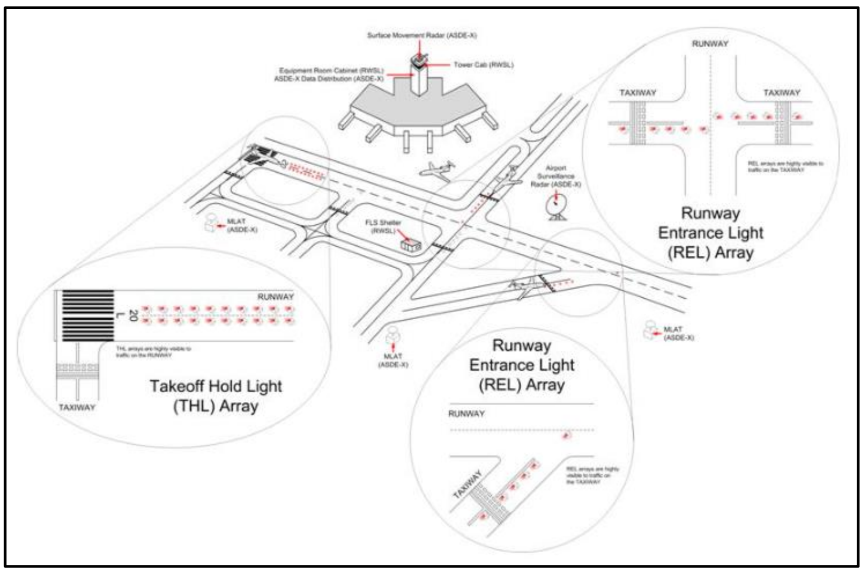
iv. Once on the ground, it is prudent to call the tower and explain the situation

C. Aircraft on the Ground
  i. Radio malfunctions should be repaired before flight
    a. If this isn't possible, call ATC and request a VFR departure without two-way radio communications
      - No radio (NORDO) procedure arrivals are not accepted at busy airports
      - If authorization is given, the pilot is advised to monitor a frequency and/or watch for light signals
  ii. If failure occurs after departing parking, watch the tower for light signals or monitor the tower frequency

D. Techniques
  i. Carry a copy of the light gun signals on your kneeboard (stressful situations can result in forgetting)
    a. Review the light signals on occasion
  ii. On a quiet night, ask the tower to demonstrate the light signals

7. Runway Status Lights (RWSL) AI.VI.A.K8

A. Fully automated system providing a direct indication that it's unsafe to enter, cross, takeoff, or land on a runway
  i. Installed at several major US airports
  ii. Processes information from surveillance systems to turn red warning lights on/off
  iii. Used in conjunction with ATC – lights & ATC instructions must agree



B. Runway Entrance Lights (REL)
  i. In-pavement red lights
  ii. Provides a warning to aircraft waiting to cross/enter a runway that there is conflicting traffic on the runway

C. Takeoff Hold Lights (THL)
  i. In-pavement red lights
  ii. Provides a warning to aircraft in position for takeoff that the runway is occupied and unsafe for takeoff

D. More details: FAA Runway Status Lights

8. Common Errors AI.VI.A.K9

A. Use of improper frequencies
B. Improper procedure and phraseology for radio communications
C. Failure to acknowledge or properly comply with, ATC clearances and instructions
D. Failure to understand or properly comply with ATC light signals

Conclusion:

Brief review of the main points

Proper radio communications begin with understanding. As long as you, the pilot, and the controller understand what each other are saying radio communication is effective and clearances can be obeyed properly.

VI.B. Traffic Patterns

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Non-Towered Airport Flight Operations (AC 90-66B), Traffic Advisory Practices at Airports without Operating Control Towers (AC 90-42 - cancelled), AIM

Objectives	The learner develops knowledge of the proper procedures, rules, and elements of the traffic pattern at controlled and uncontrolled fields. The learner will be able to demonstrate this knowledge as required in the ACS.
Key Elements	1. Entry Procedures 2. Communication 3. Orientation
Elements	1. The Pattern 2. Traffic Pattern Selection 3. Proper Spacing 4. Right-of-Way Rules 5. Common Errors 6. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the rules and elements to a proper traffic pattern and is comfortable arriving and departing from a controlled or uncontrolled field.

Instructor Notes:

Introduction:
Attention
Interesting fact or attention-grabbing story
To depart or land at an airport we're going to have to use the traffic pattern, I guess it's pretty important, huh?

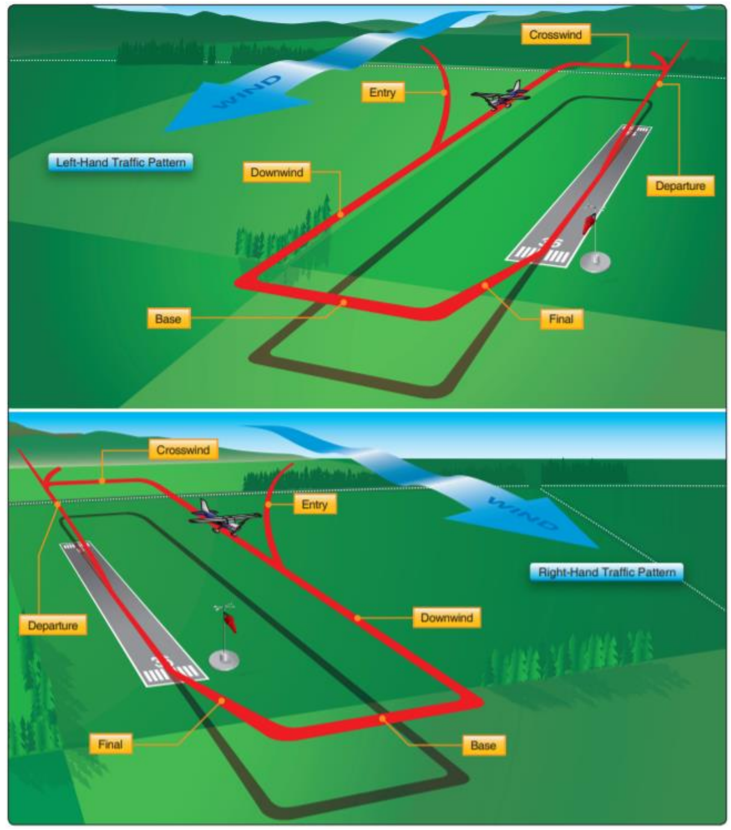
Overview
Review Objectives and Elements/Key ideas

What
Traffic Patterns involve the rules and procedures associated with flying a proper traffic pattern at a controlled and uncontrolled airport.

Why
Every flight begins and ends at an airport or other suitable landing area. For that reason, it is essential that the pilot learn the traffic rules, procedures, and pattern layouts that may be in use at various airports.

How:

1. **The Pattern**
   - A. Controlled - The pilot receives a clearance to approach/depart and pertinent pattern information
   - B. Uncontrolled - It's up to the pilot to determine traffic direction, and comply with the appropriate rules
   - C. If familiar with the basic rectangular pattern, approaches/departures will be easy at most airports
   - D. Standard Traffic Pattern
     - i. The Basics
       - a. Pattern Altitude: Usually 1,000' AGL
         - A common altitude is the key factor in minimizing collisions at uncontrolled airports
         - The Chart Supplement will usually specify nonstandard pattern altitudes
       - b. Standard Traffic Patterns: Left Turns
         - All turns are left unless otherwise noted (Chart Supplement, Tower, Airport Markings, etc.)
         - Turns should not be banked more than 30°
           - a Use rudder to maintain coordination; Do not use rudder to increase the rate of turn, this could result in a cross controlled stall
     - ii. Pattern Legs
       - a. Upwind Leg - The departure leg, flown parallel and in the same direction as runway heading
       - b. Crosswind Leg – The transition from the upwind leg to the downwind leg
         - Perpendicular to the upwind leg (90° turn)
         - Fly the crosswind leg to provide approximately ½ to 1-mile separation from the runway
       - c. Downwind Leg - Parallel to the runway of intended landing
         - The heading flown is opposite the landing runway
           - a Ex: Landing runway 10, downwind heading is 280° (no wind)
         - Approximately ½ to 1 mile from the runway
         - Before landing checks, and configuration (flaps, gear) are normally accomplished downwind
         - Descent is normally started on the downwind leg when abeam the point of intended touchdown
         - The downwind leg normally continues to a point 45° off the intended landing point, past the approach end of the runway



- a The turn to the base leg is started at the end of the downwind leg
- b Point can be adjusted based on circumstances
  1. Wind, traffic, tower, emergency, etc.

d. Base Leg - Perpendicular to the runway and the transition between downwind and final
- Ground track should be perpendicular to the extended centerline
  - a Heading is 90° off runway direction (with no wind)
- Continue the descent, adjusting pitch and power to maintain airspeed, glideslope, aim point
- Begin the turn to final to end up established on centerline

e. Establishing Final Approach
- The base leg will be adjusted depending on wind conditions
  - a The stronger the wind, the closer the base leg should be to the runway because of the decreased groundspeed on final
    1. At a slower the groundspeed on final, it takes longer to reach the runway than it otherwise would, and therefore more altitude is lost in the descent
- Turn to final should be no closer than ¼ mile at an altitude appropriate for the glide slope selected
  - a A 3° glide slope is normal; a 3° glide slope means we descend 300' every mile

f. Final - The final descent of the approach, aligned with the landing runway
- Adjust the turn from base to center the aircraft on the runway
- Crab into the wind to maintain ground track
- Adjust pitch and power as necessary to maintain airspeed, glideslope, and aim point
- Run through the Before Landing checklist again to ensure everything is complete, and ensure you have been cleared to land

iii. Departing the Pattern
   a. Climb out on the upwind leg
   b. If remaining in the pattern, turn to the crosswind leg past the departure end of the runway and within 300' of pattern altitude
   c. If departing, continue straight out, or exit with a 45° turn to the left (or right, for a right pattern)

E. Maintaining the Desired Ground Track (on any leg in the pattern)
   i. The goal is to fly a rectangular pattern regardless of the wind direction or speed
      a. The airplane will have to be crabbed into the wind to maintain a straight ground track
      b. Maintain awareness of wind in relation to the aircraft, adjust heading as necessary to maintain ground track
   ii. Visual references are very helpful in maintaining ground track
      a. Upwind: Glance behind briefly to ensure you are maintaining the runway centerline
      b. Crosswind: Use the runway as a reference; note and correct for any drift to or from the runway

c. Downwind: Place the runway centerline on a reference point on the airplane
   - EX: Place the runway centerline on the edge of a stall strip or outside the fuel cap (whatever reference works for your comfort, the aircraft, and the local pattern procedures)

d. Final: Maintain the centerline, crab as necessary to correct for the wind

e. Familiar airports may have well known references for the pattern
   - Ex: Turn base over a field, or road intersection
   - These are helpful for learning the pattern, but these specific references will not exist at other airports; be sure to teach references that can be carried from airport to airport

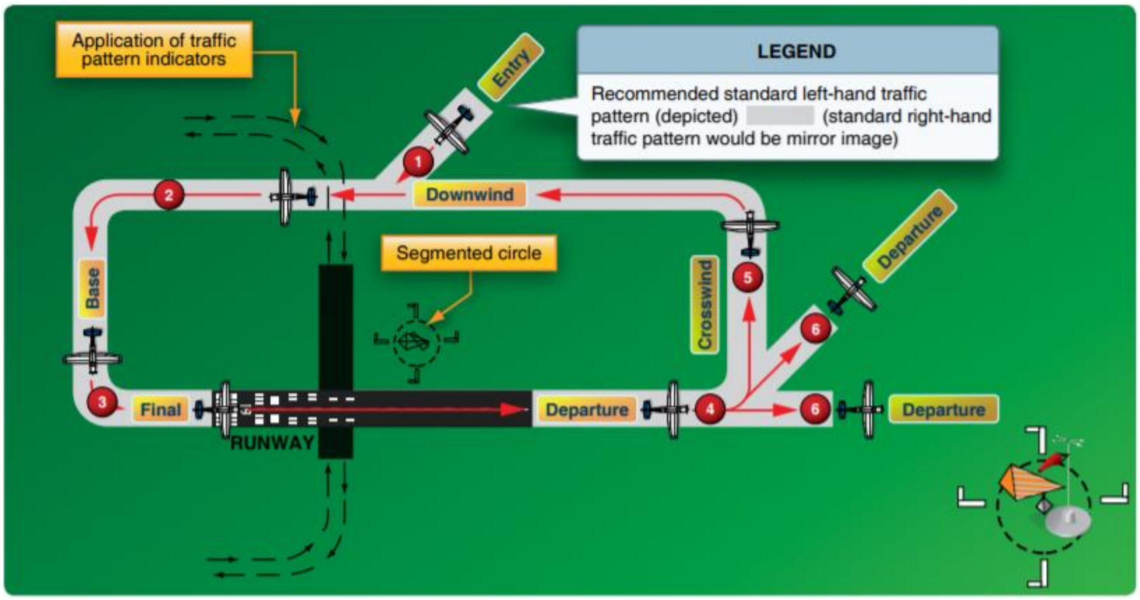
iii. Altitude & Airspeed Control

iv. Maintain a constant crosscheck - 90% outside, 10% inside

a. Know the configuration and speeds for each leg of the pattern
   - Ex: 95 kts, takeoff flaps, and gear on downwind. 85 kt descent on base, 75 kts, fully configured on final
   - Max speed in Class D airspace is 200 KIAS

b. Use small, controlled inputs to fly the airplane

c. At slow speeds, close to the ground airspeed control is very important
   - A stall within 1,000' AGL could be unrecoverable



F. Legend for the Picture Above

i. 1. Enter pattern in level flight, abeam the midpoint of the runway, at pattern altitude (1,000' AGL is recommended pattern altitude unless otherwise published)

ii. 2. Maintain pattern altitude until abeam approach end of the landing runway on downwind leg

iii. 3. Complete the final turn at least ¼ mile from the runway

iv. 4. Do no overshoot final or continue on a track that penetrates the final approach of the parallel runway

v. 5. After takeoff or go-around, continue straight ahead until beyond departure end of runway

vi. 6. If remaining in the traffic pattern, commence turn to crosswind leg beyond the departure end of the runway within 300' of pattern altitude

vii. 7. If departing the traffic pattern, continue straight out, or exit with a 45° turn (to the left when in a left-hand traffic pattern; to the right when in a right-hand traffic pattern) beyond the departure end of the runway, after reaching pattern altitude

viii. 8. Do not continue on a track that penetrates the departure path of the parallel runway

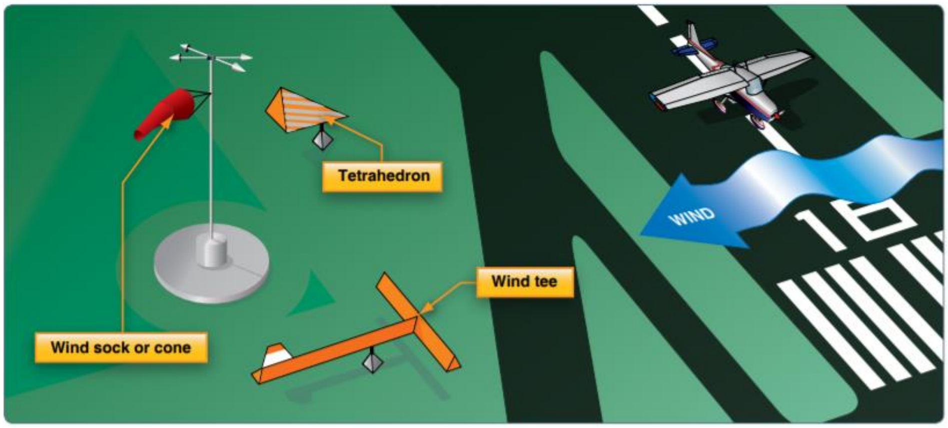
2. Traffic Pattern Selection AI.VI.B.K2, AI.VI.B.K4

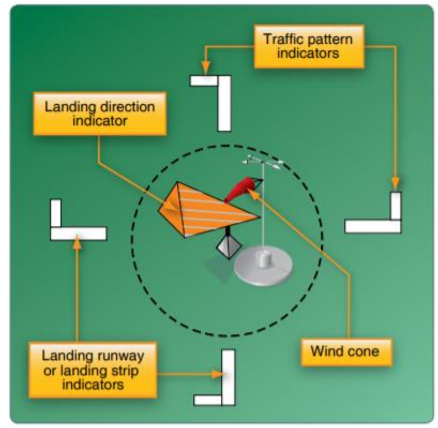
Facility at Airport	Frequency Use	Communication/Broadcast Procedures		
		Outbound	Inbound	Practice Instrument Approach
UNICOM (no tower or FSS)	Communicate with UNICOM station on published CTAF frequency (122.7, 122.8, 122.725, 122.975, or 123.0). If unable to contact UNICOM station, use self-announce procedures on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	
No tower, FSS, or UNICOM	Self-announce on MULTICOM frequency 122.9.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	Departing final approach fix (name) or on final approach segment inbound.
No tower in operation, FSS open	Communicate with FSS on CTAF frequency.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	Approach completed/terminated.
FSS closed (no tower)	Self-announce on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	
Tower or FSS not in operation	Self-announce on CTAF.	Before taxiing and before taxiing on the runway for departure.	10 miles out. Entering downwind, base, and final. Leaving the runway.	

A. Controlled Field AI.VI.B.K1
   i. Generally, ATIS will inform the pilot of the runway(s) in use
   ii. Tower provides a clearance to approach/depart as well as pertinent information about the pattern
   iii. ATC will specify pattern entry and departure procedures (Where/how to enter and depart)
   iv. During the pattern the controller may make adjustments (speed, legs lengths, turns for spacing, etc.)
      a. The pattern can be very busy –radio calls, checklists, configuration changes, and other aircraft
         - Listen closely to ATC instructions while accomplishing other tasks
            a Do not become distracted or fixated on one task, divide your attention
            b Remember to fly first – aviate, navigate, communicate
      b. Clear aggressively

B. Uncontrolled Field AI.VI.B.K1
   i. Communication
      a. There are 2 ways to communicate intentions and obtain airport/traffic info at an uncontrolled field
         - Communicating with an FSS providing advisories
            a The FSS provides wind info, runway in use, altimeter setting, known traffic, NOTAMs, etc.
               1. They are not a controller - the FSS just provides information for your use
            b Initiate contact about 10 miles out with altitude, aircraft type, and location
            c Departing aircraft should transmit tail number, type of flight, destination, services desired, and anything else applicable
         - Self-announced broadcast on the CTAF (frequency is found in the Chart Supplement and on sectionals)
            a Listen to the local weather for wind direction
               1. Provides a good idea of which runway is in use (verify with CTAF)
            b Announce your position and intentions on the CTAF frequency
            c Monitor other aircraft calls on CTAF and coordinate actions as necessary to avoid hazards
   ii. Arriving
      a. Observe other aircraft already in the pattern and conform to the traffic pattern in use
         - If there are no other aircraft, use traffic indicators/wind direction to determine runway in use

        a Look for L shaped indicators with a segmented circle (short part of the L shows turn direction)
        b Check these indicators well above pattern altitude (500' – 1,000' above pattern altitude)



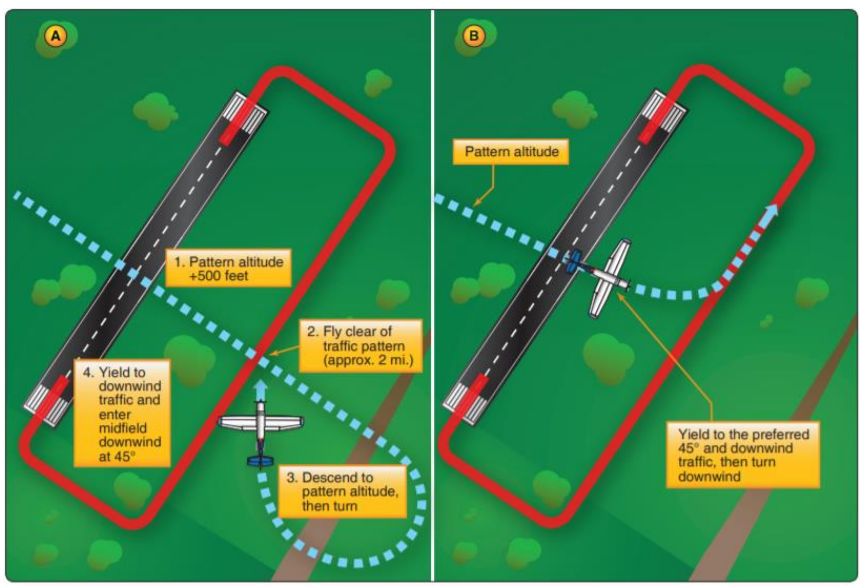


        c Pattern direction can also be determined in the Chart Supplement and on sectional charts

b. RM: Enter at pattern altitude and clear aggressively (RM: Collision Hazards)
    - Entry while descending creates collision hazards and should be avoided
        a Since you cannot see below the cowling, you could unknowingly descend onto another
    - Adjust airspeed to blend into the traffic
        a Use airspeeds recommended by the manufacturer
        b Generally, 70-80 knots for fixed-gear singles & 80-90 knots for high-performance retractable

c. Downwind Entry
    - Enter at pattern altitude at a 45° to the midfield downwind

d. Midfield Entry
    - Cross midfield at least 500' above pattern altitude
    - When well clear of the pattern (approximately 2 miles), descend to pattern altitude
    - Enter the pattern in level flight, at pattern altitude, at a 45° angle to the downwind leg, abeam the runway midpoint (preferred method, A - pictured)



e. Alternate Midfield Entry
    - Enter at pattern altitude at midfield crosswind and turn downwind (B – pictured)
    - Should not be used when the pattern is congested

f. Runway Orientation AI.VI.B.R2
    - Visualize your position in relation to the runway on the heading indicator
    - RM: Confirm the runway number with the heading indicator on all pattern legs (RM: Disorientation)
        a Downwind – reciprocal of the landing runway

b Base - 90º off (in the direction of the pattern)
c Final – Same as the runway number

iii. Departing
  a. Monitor the radio for traffic in the area
  b. Announce intentions
  c. Clear aggressively prior to takeoff and on departure
    - Radio communication is not required at an uncontrolled field
  d. The pattern can be very busy –radio calls, checklists, configuration changes, and other aircraft
    - Listen closely to CTAF while accomplishing other tasks
      a Do not become distracted or fixated on one task, divide your attention
      b Remember to fly first – aviate, navigate, communicate
  e. Clear aggressively, especially at uncontrolled airfields

3. RM: **Proper Spacing** (RM: Collision Hazards) AI.VI.B.R1

A. Be aware of other aircraft in the pattern, as well as aircraft entering and exiting the pattern
  i. Use the tower/CTAF radio calls to build a mental image of the traffic and adjust to maintain separation
    a. Uncontrolled Field: announce your intentions
    b. Controlled Field: follow the controller's instructions and/or request permission to make a change
      - Ex: 360º turn on downwind, or an extended downwind to create space
  ii. As mentioned above, maintain airspeed to blend in with the other traffic
  iii. On downwind with another aircraft on final, delay the base turn until abeam/past the other aircraft
    a. This is a common technique to provide comfortable spacing at similar airspeeds
  iv. Adjust upwind as necessary to accommodate aircraft on downwind

B. The pilot is always responsible for seeing and avoiding whether at a controlled or uncontrolled field!

C. Spacing
  i. Don't fly faster than an airplane in-front of you, or turn too early following another plane
    a. Adjust your speed to blend in
    b. Wait until you are abeam the other aircraft before making your turn
  ii. Adjust, if necessary
    a. Extend downwind, configure, and slow to approach speed earlier than normal, use s-turns, etc.
    b. If absolutely necessary, depart the pattern and re-enter

4. **Right-of-Way Rules** (FAR 91.113) AI.VI.B.K3

A. An aircraft in distress has the right-of-way over all other traffic

B. Converging
  i. If aircraft of the same category are converging, the aircraft to the other's right has the right-of-way
  ii. Different Categories Converging (basically, least maneuverable aircraft has the right-of-way)
    a. Balloon, glider, and airship have right-of-way over airplanes
    b. An aircraft towing or refueling another aircraft has the right-of-way over all engine driven aircraft

C. Approaching Head-On: Each aircraft shall alter course to the right

D. Overtaking: Aircraft being overtaken has the right-of-way; overtaking aircraft shall alter course to the right

E. Landing: Aircraft on final approach or landing have the right-of-way over aircraft in flight or on the surface
    a. Shall not take advantage of this to force an aircraft which has already landed off the runway
  ii. When two or more aircraft are approaching an airport to land, the lower aircraft has the right-of-way
    a. Shall not take advantage of this rule to cut in front of another aircraft

5. **Common Errors** AI.VI.B.K5

A. Failure to comply with traffic pattern instructions, procedures, and rules

B. Improper correction for wind drift

C. Inadequate spacing from other traffic

D. Poor altitude or airspeed control

6. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. See VII. RM Concepts – Wind Shear AI.VI.B.R3
B. See VII. RM Concepts – Wake Turbulence AI.VI.B.R3
C. See VII. RM Concepts – Distractions (Task Prioritization, Loss of SA, Disorientation) AI.VI.B.R2

Conclusion:

Brief review of the main points

Every flight begins and ends at an airport or other suitable landing area, making patterns very important.

TAKEOFFS, LANDINGS & GO-AROUNDS

VII.A. Normal Takeoff & Climb

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	To understand the procedures and requirements for a normal and crosswind takeoff and climb. The learner should be able to competently maintain control of the airplane and safely takeoff and climb with or without wind as described in the ACS.
Key Elements	1. Takeoff into the Wind 2. Left Turning Tendencies 3. *Rotation Speed (V_R - 44 knots)
Elements	1. Takeoff & Climb 2. Normal Takeoff 3. Crosswind Takeoff 4. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Model Airplane
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner can walk through a normal or crosswind takeoff on the ground, providing knowledge of normal takeoff & climb common errors. The learner also should be able to confidently demonstrate a takeoff and climb with or without a crosswind.

Instructor Notes:

Introduction:

Attention

Takeoff is one of the most basic and exciting parts of flying. Different situations regarding wind and weather, runway size and length, and the runway surface will provide different challenges for every flight.

Overview

Review Objectives and Elements/Key ideas

What

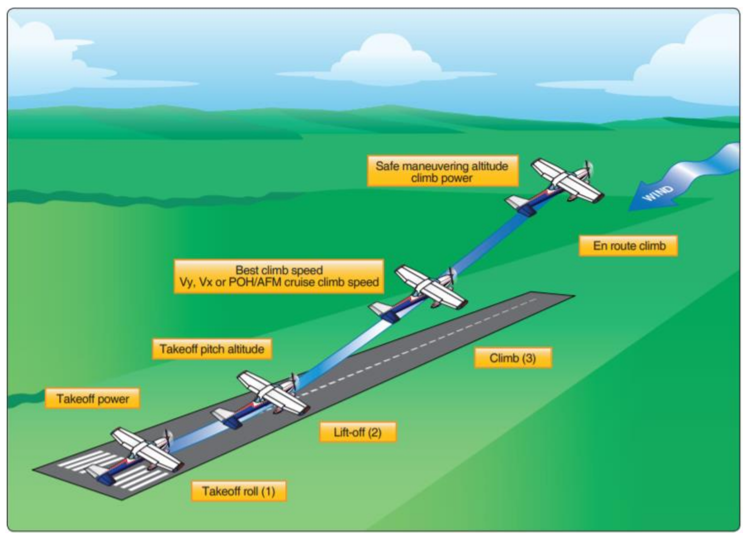
The procedures for safely guiding the airplane from the ground to the air in varying wind conditions.

Why

It is essential for every flight you will ever take! A smooth, skillful, and safe takeoff is a key element of pilot proficiency. Maneuvering near the ground can be hazardous and therefore it's important to be skilled in takeoff procedures.

How:

1. **Takeoff & Climb** AI.VII.A.K2
   A. A normal takeoff:
      i. Airplane is headed into the wind, or the wind is very light
      ii. Takeoff surface is firm and of sufficient length to gradually accelerate to normal lift-off/climb-out speed
      iii. No obstructions on the takeoff path
      iv. Overview
         a. Takeoff roll, Rotation, Initial Climb (V_X or V_Y), After takeoff checklist, Cruise climb



   B. RM: Runway Selection AI.VII.A.R1
      i. Wind: Reasons for taking off into the wind
         a. Even when motionless, a headwind provides some level of airspeed due to wind moving over the wings
         b. A plane depends on airspeed to fly, a headwind provides some of that speed before the plane is moving
         c. A headwind decreases the ground speed necessary to achieve flying speed
            - Shorter runways can be used
            - More runway is available in the case that the airplane needs to be stopped
               a The lower groundspeed also makes the airplane easier to stop
            - Reduces wear and stress on the landing gear
         d. Increased climb performance
         e. RM: Tailwind increases the required ground roll (RM: Effects of Tailwind) AI.VII.A.R2c
            - Requires the more distance to obtain the required airflow over the wings during takeoff
            - There are times that a takeoff with a tail wind is necessary
               a POH: Reference any max takeoff tailwind limitations
      ii. Aircraft Performance

a. Atmospheric Pressure
- Since air is a gas, it can be compressed or expanded, affecting density
- Changes in air density affect performance - As density increases, performance increases & vice versa

b. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
- Density varies directly with pressure - As pressure increases, density increases and vice versa
- Density varies inversely with temperature – As temp increases, density decreases and vice versa
- Density varies inversely with altitude - As altitude increases, density decreases and vice versa
- Density varies inversely with humidity – As humidity increases, density decreases and vice versa

c. How it affects Performance
- As the air becomes less dense, it reduces:
  - a Power, since the engine takes in less air
  - b Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
  - c Lift, because the thin air exerts less force on the airfoils

iii. Runway Characteristics AI.VII.A.R2e
  a. Surface: More friction associated with softer surfaces – increases takeoff roll
  b. Gradient: Upsloping runway increases takeoff roll – reference the Chart Supplement for runway gradient
  c. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
  d. Available Distance: Runway length available for takeoff

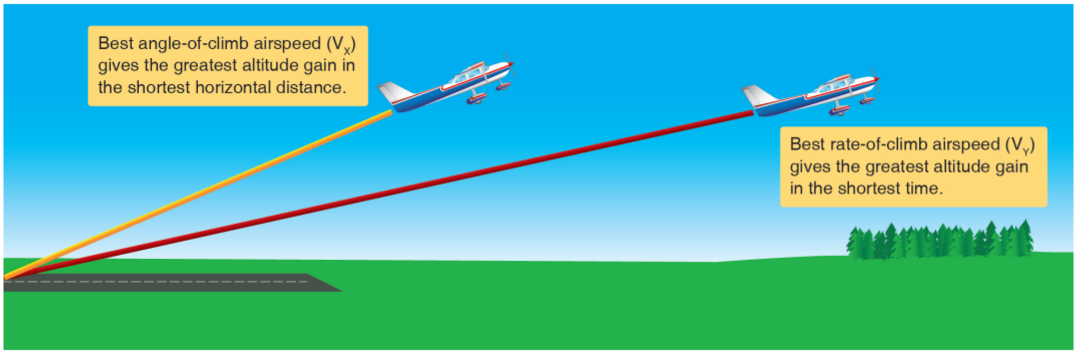
iv. Performance Charts
  a. Take into account all of the above information, and more (weight, configuration, etc.)
  b. Reference takeoff & climb performance charts (generally, takeoff distance & takeoff climb)
  - Verify required distance and climb abilities are compatible with the runway/environment

v. Pilot Capability
  a. Set and strictly adhere to personal minimums
  b. Ensure proficiency and safety

C. Configuration AI.VII.A.K4
  i. Reference the POH and Before Takeoff checklist
    a. Configuration can vary based on the aircraft and type of takeoff

D. Best Angle versus Best Rate of Climb AI.VII.A.K3
  i. Best Rate of Climb (V_Y)
    a. Performed at the airspeed producing the most altitude gain in the least time (max feet per minute)
    - Airspeed where the most excess *power* is available over that required for level flight
      - a Power is the energy the engine produces
    b. As altitude increases, the airspeed for the best rate of climb decreases
    c. The best rate of climb speed + maximum power = the aircraft's maximum climb
    - Attempts to get more climb performance by increasing pitch results in a decreased rate of climb
    d. Used in normal takeoff and climb procedures

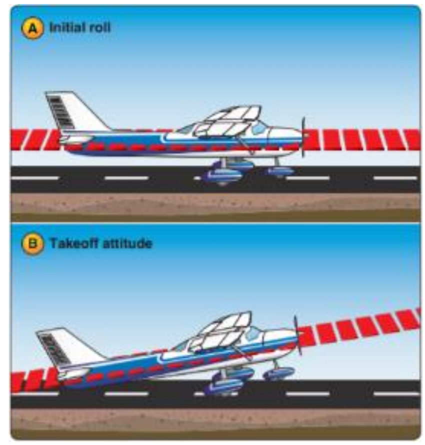
  ii. Best Angle of Climb (V_X)
    a. Performed at an airspeed that will produce the most altitude gain in the shortest distance
    - Slower than V_Y
    b. Airspeed where the most excess t*hrust* is available over that required for level flight
    - Thrust is what propels the airplane (the displaced air as a result of the spinning propeller)
    c. As altitude increases, the airspeed for the best angle of climb increases
    d. Read Thrust vs Power (on medium.com) for a short article breaking down the two terms
    e. V_X will result in a steeper climb path, but will take longer to reach altitude than a climb at V_Y
    - Therefore, V_X is used in clearing obstacles after takeoff



iii. Normal Climb (Cruise Climb)
   a. Performed at an airspeed recommended by the airplane manufacturer
      - Usually faster than the best rate of climb, but provides better cooling, control, and visibility
   b. *When we pitch for 75 or 90 knots in the DA20

2. Normal Takeoff AI.VII.A.K1

A. Takeoff Roll
   i. Taxi onto the Runway
      a. Complete the before takeoff checklist prior to taxiing onto the runway
      b. Controlled Airport
         - Never taxi onto a runway for takeoff without a specific clearance
            a Cleared for takeoff
            b Lineup and wait
            c In the case of confusion, stop the airplane and query the controller
         - Clear the area prior to crossing the hold short lines
            a Ensure there are no other aircraft on final that could become a hazard,
            b Do not taxi out onto the runway if it is not safe
      c. Uncontrolled Airport
         - Announce intentions on the CTAF to alert other aircraft of your position and intentions
         - Use other radio calls to build a mental picture of the traffic in the area and how it may affect you
         - Check final approach
            a Ensure time to takeoff before any aircraft turn onto final
            b As a general rule, don't take the runway with another airplane on final
         - Check the runway
            a Ensure the runway is clear of other aircraft, vehicles, persons, or other hazards
      d. When entering any runway, verify the runway assigned matches the runway you are on
         - Compare the runway assigned against
            a The painted runway numbers, and/or the runway hold position signs
            b The magnetic heading of the airplane, once aligned
            c The GPS position on your tablet/app, if available (for example, ForeFlight)
         - Numerous accidents have been the result of pilots unintentionally lining up on the wrong runway. Always verify you are where you intend to be
            a If there is any confusion, stop, do not takeoff, and query the controller
      e. Aligning the aircraft
         - The airplane should be carefully aligned with the intended takeoff direction, and the nose wheel positioned straight, or centered and stopped
            a *Centerline site picture: Put the centerline between the pilot's outer leg & the control stick
               1. This visual reference varies slightly from person to person and aircraft to aircraft; adjust as necessary to find a sight picture that works for you



- While taxiing onto the runway, select ground reference points aligned with the runway to aid in maintaining directional control with the runway centerline during the climb
  a For example, runway lighting, distant trees, towers, buildings, mountains, etc.

ii. Release the brakes and advance power
  a. After releasing brakes, the throttle should be advance smoothly and continuously to takeoff power
    - Be smooth with the power - abrupt power applications can result in a sharp yaw to the left
    - Once brakes are released, ensure both feet are on the rudder pedals, and not pressing on the brakes
      a Applying the brakes during the takeoff roll will increase the takeoff run
  b. Expect left yaw when power is added - be proactive to counter the yaw, but don't overcorrect
    - Right rudder is used to counteract the left turning tendencies
    - Adjust the amount of right rudder pressure to maintain the centerline site picture

iii. Gaining Speed
  a. Check engine instruments for proper operation, and verify the airspeed indicator is operating
    - Announce "gauges green," "airspeed alive"
    - Continue to monitor the engine instruments for any indication of a malfunction
    - If the airspeed indicator is not operating, and/or there is an engine malfunction, abort the takeoff and stop straight ahead
  b. Directional control is maintained through smooth, prompt, positive rudder corrections
    - Keep the nose of the airplane tracking down the centerline of the runway
      a *Visual picture - Centerline between outer leg and control stick
    - Don't use the brakes to steer
      a This will slow acceleration and possibly results in severe swerving
  c. As speed increases, the flight controls will become effective
    - As this occurs, progressively smaller rudder deflections are necessary to maintain direction
      a Plane is being flown more than taxied
    - It takes repetition to recognize and be comfortable with control pressure changes based on speed
    - Don't be over dependent on the airspeed indicator, develop a feel for the airplane

B. Lift-Off
  i. Rotation (V_R)
    a. Reaching V_R, gently pull back on the controls to initiate a nose high attitude to climb at V_Y
      - *Approximately 10° nose up
        a Varies in different aircraft
        b Varies with aircraft weight and density altitude (airplane's ability to climb)
      - This is when all flight controls become effective
      - Wings are kept level with ailerons
      - Maintain rudder to keep flying straight & coordinated
    b. Visually
      - Runway disappears as the nose pitches upward
      - Maintain the centerline, pitch, and bank, with outside references and quick glances to the instruments
        a 90% outside, 10% inside

            b Note/maintain the position of the nose on the horizon, keep wings level relative to the horizon
    c. Improper liftoff procedures
        - Don't force the plane into the air with excessive back pressure
            a Unsafe. If the aircraft is forced into the area before adequate flight speed is attained, AOA may become excessive, causing the plane to settle back onto the runway or stall
        - Insufficient back pressure or lowering the nose may cause the plane to settle back to the runway
ii. Initial Climb
    a. After rotation and initial lift-off, the plane is pitched for V_Y
        - V_Y is the speed at which the aircraft will gain the most altitude in the shortest period of time
            a V_Y + takeoff power = maximum altitude gained in a minimum amount of time.
            b Gives the pilot the most altitude in the case of an engine failure or other emergency
        - *Approximately 10°
    b. Visually
        - Set pitch and hold it, cross-check against the horizon and other visual references
            a Unless dictated otherwise, takeoff path should remain aligned with the runway centerline
                1. Identify two points inline and ahead of the runway to use as a tracking reference
            b Proper scanning is essential for maintaining attitude and direction, and avoiding collisions
    c. At takeoff power, airspeed is controlled by slight pitch adjustments using the elevators
        - The airspeed indicator is used as a check to ensure the pitch attitude is correct
        - Don't focus on the instruments, continue to scan outside references
        - When a change needs to be made:
            a Make the change with reference to the natural horizon, and momentarily hold the new attitude
                1. Due to inertia, the airplane won't accelerate/decelerate immediately with pitch changes
            b Glance at the airspeed indicator to verify the new attitude is correct
            c If correct, maintain pitch and occasionally crosscheck airspeed to ensure it is maintained
            d If incorrect, repeat pitch change/cross check procedure until the desired attitude is attained

C. *Climb Checklist
    i. Climb to 500' AGL, at which point the 'Climb Check' is performed
        a. Speed – 90 knots
        b. Fuel Pump – Off
        c. Flaps - Up
        d. Gauges – Green
        e. Lights – Off
    ii. Considerations
        a. Wait until the aircraft is at a safe altitude *and* under control to accomplish any checklists
        b. The checklist can be delayed to fly the aircraft - Aviate, Navigate, Communicate

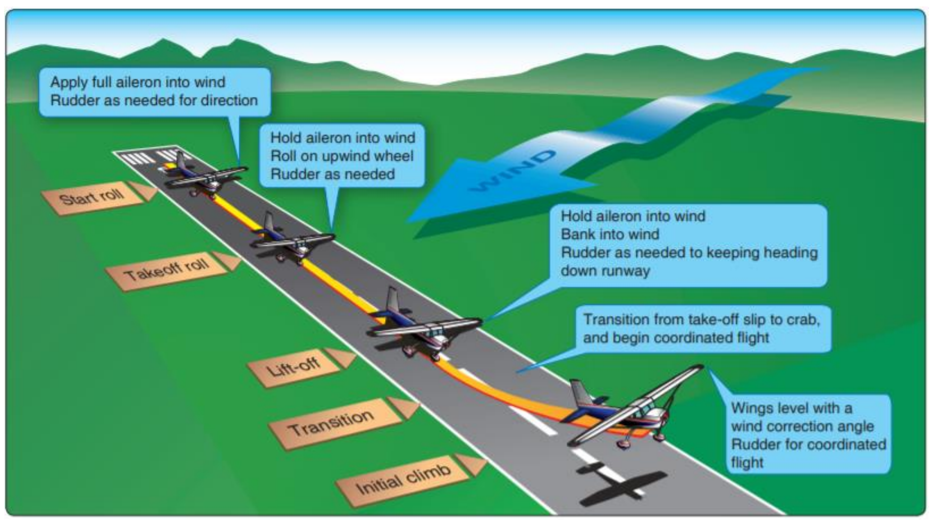
D. Common Errors AI.VII.A.K5
    i. Failure to review AFM/POH and performance charts prior to takeoff
    ii. Failure to adequately clear the area prior to taxiing into position on the active runway
    iii. Abrupt use of the throttle
    iv. Failure to check engine instruments for signs of malfunction after applying takeoff power
    v. Failure to anticipate left turning tendency on initial acceleration & Overcorrecting for left turning tendency
    vi. Relying solely on the airspeed indicator rather than developing an understanding of visual references and tracking clues of airplane airspeed and controllability during acceleration and lift-off
    vii. Failure to attain proper lift-off attitude
    viii. Inadequate compensation for torque/P-factor during initial climb resulting in a sideslip
    ix. Over-control of elevators during initial climb-out and lack of elevator trimming

x. Limiting scan to areas directly ahead of the airplane, causing a wing to drop immediately after lift-off
xi. Failure to attain/maintain best rate-of-climb airspeed (V_Y) or desired climb airspeed
xii. Failure to employ principles of attitude flying during climb-out, resulting in "chasing" the airspeed indicator

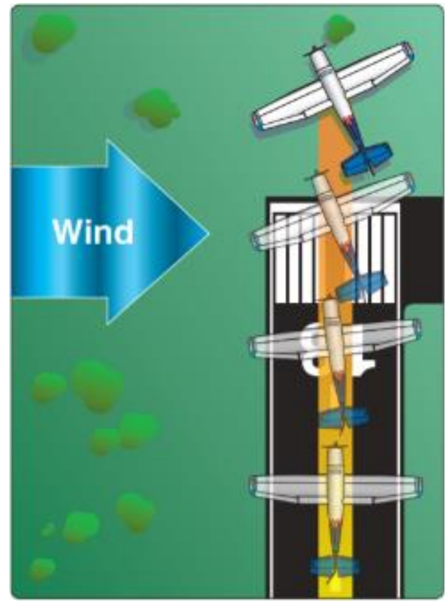
3. Crosswind Takeoff AI.VII.A.K1

A. Basics
   i. Basic steps of a normal takeoff are the same for a crosswind takeoff
      a. Differences ensure centerline is maintained and a smooth takeoff with wind pushing across the runway
   ii. Closely parallels crosswind corrections used for taxiing
   iii. Aileron is applied into the wind, and rudder maintains the centerline
      a. Aileron keeps the wings level during the takeoff roll
         - Start fully deflected into the wind & decrease pressure as ailerons become more effective
      b. Rudder keeps the nose tracking down the runway centerline
         - On the ground, the plane weathervanes, or points, into the wind
         - Rudder counters the weathervane to keep aligned with the centerline
         - Rudder is generally applied in the opposite direction of the ailerons
            a Right rudder is required to counter the left turning tendencies, but:
               1. If there is a crosswind from the left, additional right rudder will be required
               2. If there is a crosswind from the right, less right rudder than normal will be required
      c. Once established in the climb, transition from the sideslip to a crab
   iv. Prevents skipping, sideways movement across the runway, and potentially severe side stresses on the gear

B. Takeoff Roll
   i. Taxi onto the Runway
      a. Complete the before takeoff checklist prior to taxiing onto the runway
      b. Carefully align with the centerline and center the nosewheel
   ii. With a crosswind (windsock, ATIS, other indicators) hold FULL aileron INTO the wind as the roll is started
      a. Raises the upwind aileron, to impose a downward force and prevent the crosswind from raising the wing



   iii. Release the brakes
      a. Same as a normal takeoff, but with full aileron into the wind
      b. Smoothly and continuously advance the throttle to takeoff power
      c. Apply rudder to counter left turning tendencies & weathervane
   iv. Gaining Speed
      a. As speed increases, ailerons become more effective, and the crosswind becomes more of a relative headwind
         - Full aileron pressure into the wind should gradually be reduced
         - Some aileron pressure will be maintained – The crosswind doesn't entirely go away
         - Adjust rudder to continue straight down the centerline



- b. Don't be mechanical, rather sense the need for aileron input through feel and visual indications
    - a If the wings are tilting in relation to the horizon, use aileron to level them
  - Don't use excessive aileron input in the latter stage of the takeoff roll,
    - a Can result in a steep bank into the wind at lift-off (putting the wing near the runway surface)
- c. Avoid premature lift-off resulting in side-skipping
  - If the crosswind correction is not held properly, a skipping action may result
  - Side-skipping imposes severe stresses on the landing gear and could result in structural failure

C. Lift-Off
- i. In a significant crosswind, hold the main gear on the ground longer to ensure a smooth but definite takeoff
  - a. Allows the airplane to leave the ground with more positive control and prevent side loading the gear
- ii. Sufficient aileron should be held into the wind so that immediately after liftoff the aircraft is side slipping into the wind to counteract drift
  - a. As the nose wheel is being raised, the aileron control into the wind may result in the downwind wing rising first and the downwind main wheel lifting off first
    - This is acceptable and preferred to side skipping
- iii. Once the plane leaves the ground drift correction needs to be maintained
  - a. Visually
    - Runway will begin to disappear as the nose pitches upward
    - Maintain the centerline, pitch, and bank (slip) with outside references and instrument indications
  - b. Instrument Indications
    - *Pitch to approximately 10° to maintain V_Y
      - a Make small adjustments as necessary for airspeed

D. Initial Climb
- i. Once the climb is established, transition to a crab into the wind
  - a. Sideslip creates excess drag and reduces climb performance
  - b. Turn into the wind, level the wings, use rudder for coordination
- ii. Visually
  - a. Use an outside scan to maintain proper pitch/bank attitude
    - Essential for a safe takeoff
  - b. Select two points ahead of, and in line with the runway
    - Keep them in alignment during the crab
  - c. Frequent checks of the ground track should be made to ensure you remain on the extended centerline
  - d. Don't focus on the instruments
- iii. The remainder of the climb is the same as a normal climb

E. *Climb Checklist
- i. Climb to 500' AGL, at which point the 'Climb Check' is performed
  - a. Speed – 90 knots
  - b. Fuel Pump – Off
  - c. Flaps - Up

d. Gauges – Green
e. Lights – Off

F. Common Errors AI.VII.A.K5
  i. Using less than full aileron pressure into the wind initially on the takeoff roll
  ii. Mechanical use of aileron control rather than judging lateral position of airplane on runway from visual clues and applying sufficient aileron to keep airplane centered laterally on runway
  iii. Side-skipping due to improper aileron application
  iv. Inadequate rudder control to maintain airplane parallel to centerline and pointed straight ahead in alignment with visual references
  v. Excessive aileron input in the latter stage of the takeoff roll resulting in a steep bank into the wind at lift-off.
  vi. Inadequate drift correction after lift-off

4. RM: **Hazards & Emergencies**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Takeoff AI.VII.A.R3a
B. VII. RM Concepts – Engine Failure AI.VII.A.R3b
C. VII. RM Concepts – Wind Shear AI.VII.A.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.A.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.A.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.A.R5
G. VII. RM Concepts – Collision Hazards AI.VII.A.R4
H. VII. RM Concepts – Runway Incursion AI.VII.A.R7

Conclusion:

Brief review of the main points

Not every takeoff will be the same and therefore adjustments will have to be made. A strong understanding of what is involved in a normal and crosswind takeoff is essential to every flight.

VII.B. Normal Approach & Landing

References: Airplane Flying Handbook (FAA-H-8083-3), Procedures during Taxi Operations (AC 91-73), Aviation Weather Handbook (FAA-H-8083-28), POH/AFM

Objectives	The learner should be able to perform a normal approach and landing as prescribed in ACS. The approach and landing should be performed satisfactorily with or without a crosswind, and with the necessary corrections based on the situation.
Key Elements	1. Stabilized Approach 2. Smooth, Controlled Roundout 3. Hold the airplane inches above the ground before touching down 4. Don't Side Load the Aircraft
Elements	1. Runway Selection 2. Downwind Leg 3. Base Leg 4. Final Approach 5. Roundout 6. Touchdown 7. After-Landing Roll 8. Common Errors 9. Crosswind Approach 10. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can fly a coordinated, stabilized approach, transitioning into a smooth roundout and touchdown without side loading the airplane, with or without a crosswind.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The landing is the most difficult, and most fun part of flying. At least according to the passengers, if doesn't matter how good the flight was if the landing was bad.

Overview

Review Objectives and Elements/Key ideas

What

A normal approach and landing involves the use of procedures for what is considered a normal situation; that is, when engine power is available, the wind is light or final approach is made directly into the wind, the final approach path has no obstacles, and the landing surface is firm and of ample length to gradually bring the plane to a stop.

Why

It's really a good skill to have when we decide we want to land the plane. Not only that, but the factors involved, and procedures used also have applications to the other-than-normal approaches and landings.

How:

1. **Runway Selection** AI.VII.B.K3, AI.VII.B.R1
   - A. Wind
     - i. Headwind
       - a. Decreases groundspeed and therefore landing distance
       - b. Reduced groundspeed requires a slower rate of descent on final
     - ii. RM: Tailwind AI.VII.B.R2c
       - a. Increases groundspeed and therefore landing distance
       - b. Increased groundspeed requires a higher rate of descent on final
     - iii. RM: Ensure any crosswind is within limits (personal & POH) (RM: Effects of crosswind) AI.VII.B.R2a
   - B. Aircraft Performance
     - i. Atmospheric Pressure
       - a. Since air is a gas, it can be compressed or expanded, affecting density
       - b. Changes in air density affect performance - As density increases, performance increases & vice versa
     - ii. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
       - a. Density varies directly with pressure - As pressure increases, density increases and vice versa
       - b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
       - c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
       - d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
     - iii. How it affects Performance
       - a. As the air becomes less dense, it reduces:
         - Power, since the engine takes in less air
         - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
         - Lift, because the thin air exerts less force on the airfoils
       - b. Density Altitude & Landing
         - Affects power requirements on approach & climb capability in the case of a go-around
         - Higher density altitude = higher true airspeed which increases the landing roll

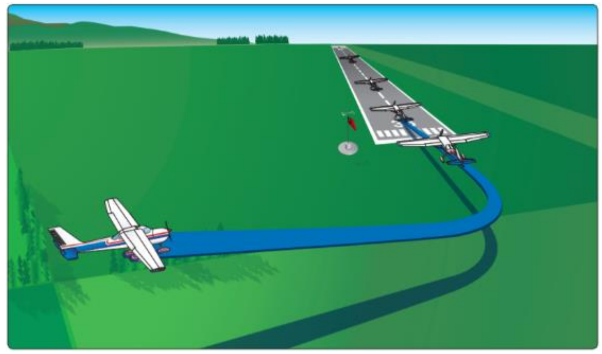
C. RM: Runway Characteristics AI.VII.B.R2e
   i. Surface: More friction associated with softer surfaces – decreases landing roll
   ii. Gradient: Down sloping runway increases landing roll – reference the Chart Supplement for runway gradient
   iii. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
   iv. Available Distance: Runway length available for landing
D. Performance Charts
   i. Take into account all of the above information, and more (weight, configuration, etc.)
   ii. Reference landing & climb performance charts (generally, landing distance/performance & climb performance or balked landing climb charts)
      a. Verify required distance and climb abilities are compatible with the runway/environment
E. Pilot Capability
   i. Set and strictly adhere to personal minimums (runway length/width, winds, weather, etc.)
   ii. Ensure proficiency and safety
F. Limitations are found in Chap 2 of the POH
   i. Applicable limitations can include maximum weights, crosswind/tailwind limitations, minimum runway length/width, flap/gear extension speeds, stall speeds, center of gravity limitations, etc.

2. Downwind Leg

A. Parallel to the runway of intended landing, and normally at 1,000' AGL
   i. Pattern altitude can vary, be aware of local procedures
B. Checklists
   i. Complete the Before Landing Checklist at the midpoint of the downwind leg
C. *Abeam the landing threshold
   i. Begin the descent
      a. Reduce power to 1500 RPM
      b. Extend takeoff flaps
      c. Airspeed - 75 knots
         - Maintain pattern altitude, allowing the airspeed to slow to 75 knots
         - Just before reaching 75 knots, establish the pitch attitude to maintain the airspeed in the descent
D. 45° angle from the runway threshold
   i. At the 45° point begin the turn to base
      a. Shallow to medium bank – recall Rectangular Course procedures to compensate for wind
   ii. At the 45° point the airplane has usually descended approximately 200' (800' AGL)
      a. This varies between aircraft

3. Base Leg

A. The leg prior to turning final; perpendicular to the approach end of the runway of intended landing
   i. Must judge the altitude & distance from which a stable descent results in landing at the desired spot
   ii. Distance of the base leg from the runway depends on altitude, wind, and the amount of flaps used
      a. When there is a strong wind on final, or the flaps are used to produce a steep angle of descent, the base leg must be closer to the runway than with a light wind or no flaps
B. Configuration
   i. *Airspeed - 70 knots
      a. Adjust pitch/power to slow from 75 to 70 knots
C. Drift Correction
   i. Ground track should be perpendicular to the runway
   ii. It is common for a crosswind to be pushing the airplane away from the runway
      a. This is because landing is made into the wind
      b. Crab into the wind to maintain the course
D. The Turn to Final



i. Medium to shallow bank turn should align the airplane with the centerline of the runway
   a. Recall Rectangular Course and the effects of wind on the bank angle
   b. No more than 30º of bank
      - Stall speed increases rapidly above 30º of bank, very unsafe when slow and close to the ground
   c. In the case a steep bank is necessary, a go around is recommended
      - A go around is highly preferred over a steep bank and/or a cross controlled situation

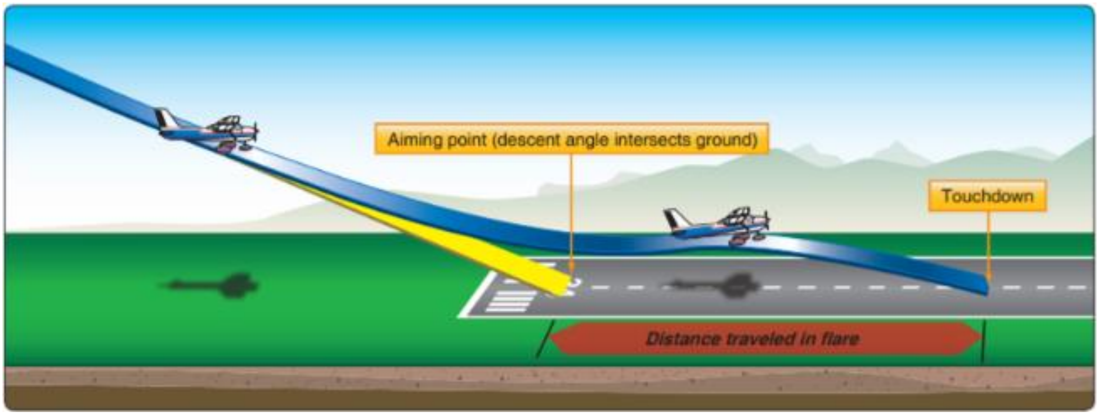
ii. *Usually a descent of approximately 200’ is made on the base leg (about 600’ AGL to start the turn to final)
   a. Varies based on aircraft, and conditions (terrain, obstructions, flap settings, etc.). Adjust as required
   b. On a 3º glidepath (which is equal to 300’ per nm), 600’ AGL is a two-mile descent to the runway

4. Final Approach

A. Longitudinal axis is aligned with the runway center line and the final descent to the landing runway is made

B. Configuration
   i. Gear down, Landing Flaps, *Airspeed – 65 knots
      a. Adjust pitch and power to establish final approach speed
      b. Strong/Gusty Winds: Increase speed on final approach: Approach speed + ½ the gust factor
         - Ex: Wind at 12 knots gusting to 20 (8 knot gust factor)
            a Approach at 65 knots + 4 knots = 69 knots (ensure landing distance is acceptable)
   ii. Landing Checklist

C. A Stable Approach AI.VII.B.K2
   i. A stabilized approach is one in which the pilot establishes and maintains a constant angle glidepath towards a predetermined point on the landing runway. It is based on the pilot’s judgement of certain visual cues and depends on the maintenance of a constant final descent airspeed and configuration
      a. Objective is to descend at an angle and airspeed that allows the plane to reach the desired touchdown point at a speed resulting in minimal float just before touchdown, in essence, a semi-stalled condition
      b. A stabilized approach is a safe approach
   ii. Controlling the Descent
      a. Power and pitch are adjusted to maintain a stabilized approach and glide slope
         - Configured at final approach speed – below LD_{MAX} and in the Region of Reverse Command
            a Pitch is used to maintain airspeed
            b Power is used to maintain altitude, or glidepath
      b. A change in any of the variables requires a coordinated change in the other controllable variables
         - For example, if the pitch attitude is raised too high without an increase in power the airplane settles rapidly and touches down short of the desired spot
            1. For this reason, never try to stretch a glide by applying back-elevator pressure alone to reach the desired landing spot
            2. The gliding distance is shortened if power is not increased simultaneously
         - The proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
            a If the approach is too high, reduce power and lower the nose to maintain airspeed
            b If the approach is too low, add power and raise the nose to maintain airspeed
            c Stay on airspeed
   iii. Angle of Descent & Aiming Point



a. The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it will strike the ground
   - An airplane descending on final approach at a constant rate and airspeed is traveling in a straight line toward a spot on the ground ahead (the aiming point)
      a This spot is not the spot on which the airplane will touchdown because some float occurs during the round out/flare

b. Select an aiming point in front of the point of intended touchdown
   - *Approximately 400 to 500' in front of touchdown to allow for the airplane's float
      a This is equal to 2 to 2½ stripes prior to your intended touchdown point
      b Varies between aircraft. Select a point appropriate to your plane's float characteristics

c. Keep the aiming point steady on the wind screen
   - To a pilot moving straight ahead toward an object, the aiming point appears to be stationary in the windscreen, it does not move
      a Objects in front of and beyond the aiming point do appear to move as the distance is closed
      b If the aiming point begins to move in the windscreen, the descent path has changed, and you are no longer aiming at the desired point. Corrections need to be made
   - If the point begins to move up on the windscreen, the airplane is getting too low
      a Add power and raise the nose to maintain airspeed
         1. The same airspeed with a higher power setting will result in a slower descent, or a climb if enough power is added
   - If the point begins to move down on the windscreen, the airplane is getting too high
      a Reduce power and lower the nose to maintain airspeed
         1. The same airspeed with a lower power setting will result in a steeper descent
   - Small, proactive corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway

iv. Runway Image

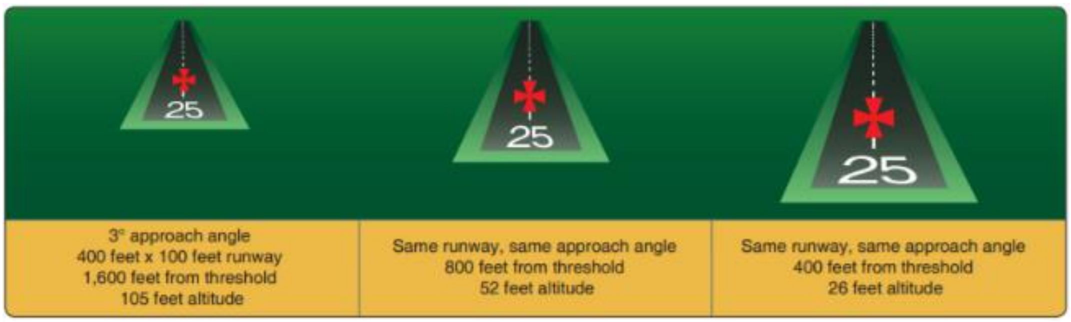
a. A normal glidepath is 3° (or a 300' per nm descent)
   - Over time, the pilot will learn the approach site picture and can apply the following principles

b. Too High: The runway will elongate and become narrower
   - Overhead view of the runway

c. Too Low: The runway will shorten and become wider
   - Flat view of the runway

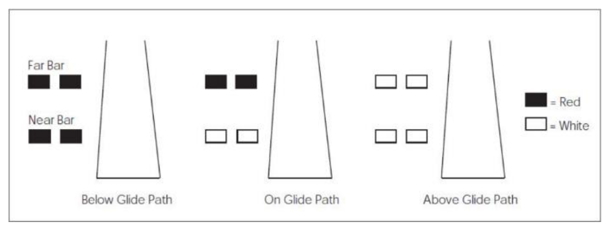
d. On Descent Path: The runway will be between overhead and flat

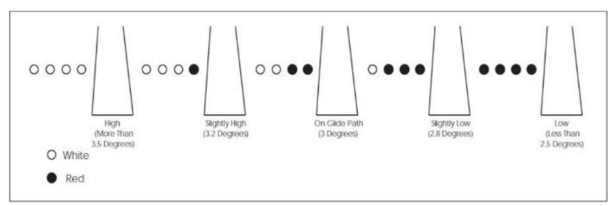
e. The runway should also maintain the same shape as the pilot continues down the approach path
- From the flight deck, the runway is seen as a trapezoid with the far end looking narrower than the approach end and the edge lines converging ahead
- Continuing the approach, the image is still a trapezoid, but of proportionately larger dimensions



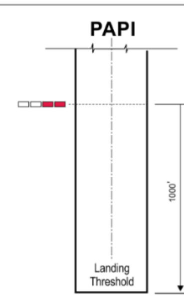
v. Visual Approach Lighting

a. Visual Approach Slope Indicator (VASI)
- Visual descent guidance during approach
- Visible from 3-5 miles during day and to 20 or more at night
  - a Obstruction clearance within ± 10° of the centerline and 4 NM from the threshold
- Two Bar VASI (most common – top pic to right)
  - a Below glidepath: All red
  - b On glidepath: 2 red & 2 white (normally 3°)
  - c Above glidepath: All white





b. Precision Approach Path Indicator (PAPI)
- 4 lights perpendicular to the runway
- Provides visual descent guidance during the approach to a runway
  - a On glidepath: 2 red & 2 white
  - b Below glidepath: 3 or 4 red
  - c Above glidepath: 3 or 4 white
- Designed to reduce controlled flight into terrain and runway over/underruns



vi. Effects of Wind

a. Rate of descent
- The greater the headwind, the lower the rate of descent (more time to cover the same distance)
- The lower the headwind or greater the tailwind, the higher the rate of descent (less time)

b. Concepts discussed/site pictures remain the same - Still on a 3° glidepath

D. Landing Clearance

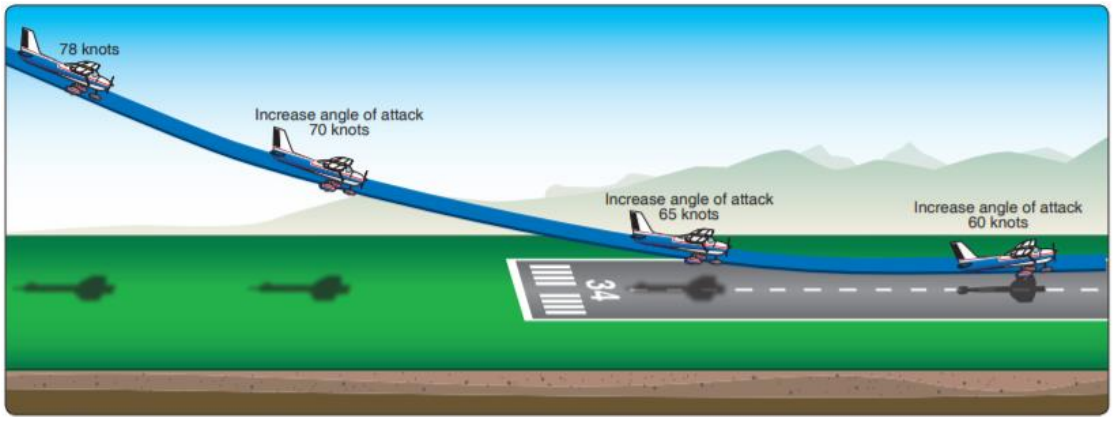
i. Ensure the controller gave you landing clearance, it was understood, and was read back

a. The landing clearance needs to be for the specific runway
    - Query and clarify if unsure or unclear about the instructions

ii. If clearance to land has not been obtained, or there is uncertainty, do not land

5. Roundout

A. A slow, smooth transition from a normal approach attitude to a landing attitude, gradually rounding out the flight path to one that is parallel with, and within a very few inches of the runway



B. Estimating Height and Movement
  i. Visual focus should not be fixed on any one side or to any one spot ahead
    a. Focus should change slowly from a point just over the nose to the desired touchdown zone and back
    b. Maintain awareness of the distance from either side of the runway with peripheral vision
  ii. Speed and Vision
    a. Speed blurs objects at close range
      - Ex: Car at high speed. Nearby objects seem to merge/blur together, farther out objects are clear
        - a The driver subconsciously focuses the eyes sufficiently far ahead to see objects distinctly
    b. The distance at which vision is focused should be proportionate to the speed of the airplane
      - As speed is reduced, the distance the pilot focuses ahead of the airplane should be brought closer
    c. Focusing too close will result in a blurred reference
      - Reactions will be too abrupt or too late
      - Tendencies include: Overcontrolling, high roundout, and full stall or drop in landings
    d. When focused too far, the ability to judge the closeness of the ground is lost
      - Reactions tend to be slow as there does not seem to be a necessity for action
      - Tendencies include late or little to no flare, and landing nose first
    e. If focus is gradually changed, being brought progressively closer as speed is reduced, the time interval and the pilot's reaction are reduced and the whole landing process smoothed out

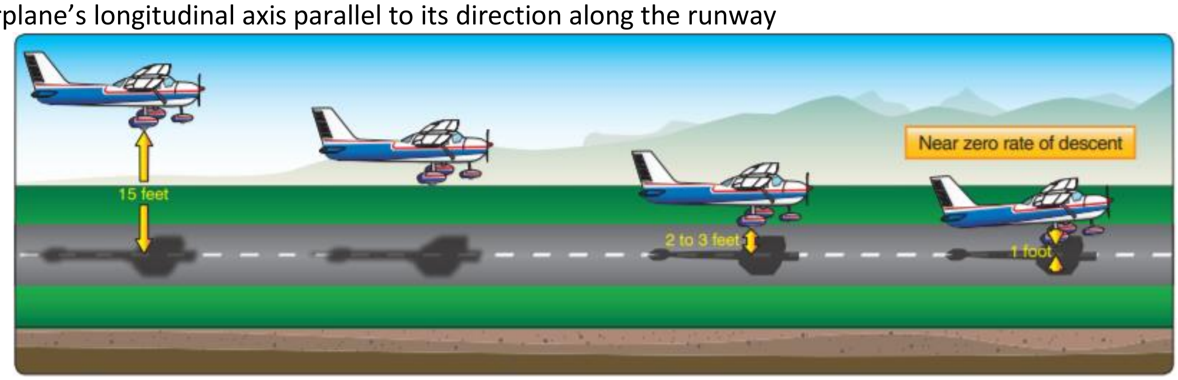
C. Starting the Roundout
  i. The roundout is started approximately 10 to 20' above the ground
    a. Varies between aircraft, and the rate of descent
  ii. Power is reduced to idle and back elevator is slowly applied, gradually increasing pitch and AOA
    a. Begins putting the nose of the airplane in the desired landing attitude
    b. AOA is increased at a rate that will allow the airplane to continue settling slowly as airspeed decreases
      - If angle of attack is increased too rapidly, the airplane will climb

D. Decreasing Lift, Increasing Pitch Attitude
  i. With the power at idle, airspeed is decreasing. As airspeed decreases, the pilot increases the angle of attack which momentarily increases lift and decreases the rate of descent
  ii. Airspeed will continue to decrease causing lift to decrease again
    a. This must be controlled by raising the nose and further increasing the angle of attack

        iii. Airspeed is being decreased to touchdown speed, while lift is being controlled with back pressure so that the airplane will settle gently onto the runway
    E. Rate of the Roundout
        i. The rate at which the roundout is executed, depends on the height above the ground, the rate of descent, and the pitch attitude
            a. High Roundout
                - Executed more slowly to allow descent to the ground while proper landing attitude is established
            b. Low Roundout
                - Executed faster to obtain the proper landing attitude before striking the runway surface
            c. High Rate of Descent
                - If the airplane appears to be descending rapidly, the increase in pitch attitude must be made at a correspondingly high rate to arrest the rate of descent and obtain the proper landing attitude before striking the runway surface
            d. Low Rate of Descent
                - When the airplane appears to be descending very slowly, the increase in pitch attitude must be made at a correspondingly slow rate
                - A high rate can lead to a rapid airspeed loss followed by an increased rate of descent to the runway
            e. High Pitch Attitude (ex: full flap landing)
                - If the airplane is already in a high pitch attitude, the roundout should be executed more slowly to prevent an excessively high pitch attitude
            f. Low Pitch Attitude (ex: no flap landing)
                - If the airplane is in a low pitch attitude, the roundout should be executed at a faster rate to obtain the proper landing attitude prior to touching down
            g. Note: Once the roundout has been started, the elevator control should not be pushed forward
                - If necessary, relax back pressure or just hold it constant as the airspeed decreases
    F. Always keep one hand on the throttle (within reason)
        i. Be prepared to apply immediate power or initiate a go around

6. Touchdown & After Landing Roll

    A. The gentle settling of the airplane onto the landing surface at the minimum controllable airspeed with the airplane's longitudinal axis parallel to its direction along the runway



    B. Ideal Landing
        i. Hold the airplane's wheels a few inches off the ground as long as possible with the elevators
        ii. In most cases, if the wheels are 2-3' off the ground, the plane will be settling too fast for a gentle touchdown
            a. The descent must be further reduced with further back-elevator pressure
    C. Longitudinal Axis
        i. The longitudinal axis should be exactly parallel to the direction the airplane is moving along the runway
            a. Failure to do this imposes severe side loads on the landing gear
            b. Don't land while drifting

        c. More below, in the crosswind approach and landing section
- D. Rudder Control
    - i. Less rudder than normal is needed
        - a. The airplane will fly almost coordinated on its own
        - b. With the engine at idle, there are little to no left turning tendencies
            - The main concern with the rudder during landing is to align the longitudinal axis of the airplane with the runway centerline in the case of a crosswind (more below)
- E. After touchdown
    - i. Maintain back-elevator pressure
        - a. Hold the nosewheel off the ground until the airplane decelerates
        - b. Maintains a positive angle of attack for aerodynamic braking
    - ii. As speed decreases, fly the nosewheel to the ground (don't let it fall/slam to the ground)
        - a. Gradually relax elevator pressure to allow the nosewheel to gently settle to the runway
        - b. This permits steering with the nosewheel, and better braking action since the entire weight of the airplane is on the wheels (rather than the wings)
        - c. Prevents skipping and/or floating after touchdown

7. After-Landing Roll

- A. The deceleration of the airplane to the normal taxi speed, or when the airplane has been brought to a complete stop when clear of the landing area
- B. Directional Control on the Ground
    - i. Rudder
        - a. The rudder serves the same purpose on the ground as it does in the air – the yaw of the airplane
            - With the nosewheel on the ground, use the rudder to steer the airplane on the ground
            - Rudder effectiveness is dependent on airflow which is dependent on the speed of the plane
                - a As speed decreases throughout the landing roll, the steerable nose provides more positive directional control
        - b. The airplane will tend to weathervane (or point) into the wind
            - With the main wheels acting as a pivot point, and a greater surface area exposed to the crosswind behind that pivot point, the airplane tends to point, or weathervane, into the wind
            - Use rudder to maintain directional control
    - ii. Aileron Control
        - a. Used to keep the wings level
        - b. As airspeed decreases during the landing roll the ailerons become less effective, therefore increasing aileron must be applied into a crosswind to keep the upwind wing from rising
    - iii. Be alert throughout the landing roll
        - a. Be alert for directional control difficulties due to the ground friction on the wheels
            - Loss of Directional Control
                - a May lead to an aggravated, uncontrolled, tight turn on the ground (ground loop)
                    1. Combination of centrifugal force acting on the center of gravity and ground friction of the main wheels resisting it during the ground loop may cause the airplane to tip or lean enough for the outside wingtip to contact the ground
                    2. This could impose a sideward force that could collapse the landing gear
        - b. Remain vigilant throughout the landing roll and keep positive control of the airplane
            - Accidents occur when pilots abandon vigilance and positive control
            - Don't assume that because the airplane is on the ground your work is done
- C. Braking
    - i. The brakes serve the same primary purpose as the brakes on a car – to reduce speed while on the ground

a. In airplanes, they are also used to aid in directional control when the rudder is insufficient
  - Brake pressure can be applied in the direction of a turn to assist the rudder

ii. Using the Brakes
  a. With toe brakes, the pilot slides the toes or feet up from the rudder pedals to the brake pedals
    - If rudder pressure held at the same time braking is needed, do not release the rudder pressure
  b. Brake pressure is applied by pushing forward on the toe pedals
  c. During the ground roll, the airplane's direction of movement can be changed by carefully applying pressure on one brake or uneven pressure on each brake in the desired direction
    - Caution must be exercised when applying brakes to avoid overcontrolling, especially at high speeds

iii. Effective Braking
  a. Put maximum weight on the main wheels after touchdown
    - The nosewheel should be lowered to the runway to maintain directional control
    - After the nose is down, back pressure is applied without lifting the nosewheel off the ground
      a This enables directional control while keeping weight on the main wheels
      b If the pilot were to brake without holding back pressure, the nose tends to pitch down which transfers weight from the main wheels to the nosewheel
        1. Does not help braking. Maximum weight should be on the main wheels
  b. Gently and evenly apply the brakes
    - Maximum brake effectiveness is just short of the point where skidding occurs
      a Maximum braking is not necessary in most landings
      b If the brakes are applied so hard that skidding takes place, braking becomes ineffective
        1. To stop skidding, release the brake pressure and reapply the brakes with less force
    - Effectiveness is not increased by applying, releasing & reapplying brakes (pumping the brakes)
      a Apply the brakes firmly and smoothly
  c. Ensure feet are not on the brakes at touchdown, this could result in lost control and blown tires

D. Exiting the Runway
  i. Have a plan of where you plan to exit the runway and how to taxi to your destination
  ii. Review and be familiar with potential hot spots (be extra cautious for traffic at these spots)
  iii. Listen to, and ensure understanding of the controller's instructions
    a. Vital to avoiding incursions
    b. Query the controller if unsure of the instructions

E. After Landing Checklist once safely clear of the runway

8. Common Errors (Normal Approach & Landing) AI.VII.B.K5

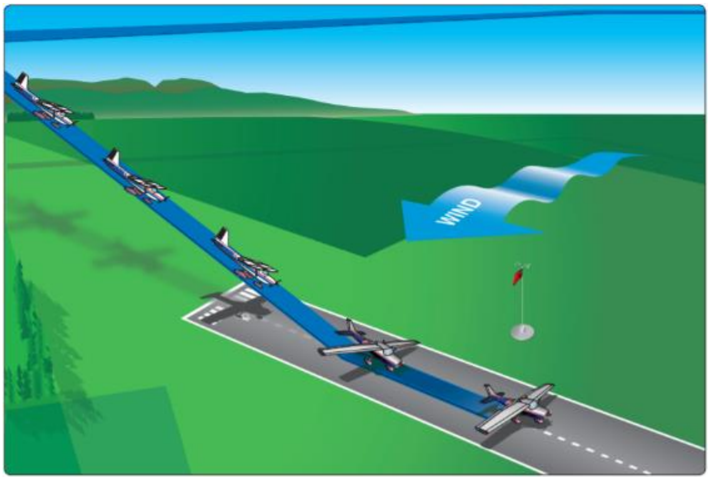
A. Failure to complete the landing checklist in a timely manner
B. Inadequate wind drift correction on the base leg.
C. An overshooting, undershooting, too steep, or too shallow a turn onto final approach.
D. A skidding turn from base leg to final approach as a result of overshooting/inadequate wind drift correction.
E. Poor coordination during turn from base to final approach.
F. Unstable approach.
G. Failure to adequately compensate for flap extension.
H. Poor trim technique on final approach.
I. Attempting to maintain altitude or reach the runway using elevator alone.
J. Focusing too close to the airplane resulting in a too high round out.
K. Focusing too far from the airplane resulting in a too low round out.
L. Touching down prior to attaining proper landing attitude.
M. Failure to hold sufficient back-elevator pressure after touchdown.
N. Excessive braking after touchdown.

O. Loss of aircraft control during touchdown and rollout

9. RM: Crosswind Approach (RM: Effects of crosswind) AI.VII.B.K1, AI.VII.B.K4, AI.VII.B.R2a

A. A landing which must be made while the wind is blowing across rather than parallel to the landing direction
B. The same basic principles apply to a crosswind approach and landing as a normal approach and landing
C. Two methods of accomplishing a crosswind approach and landing
  i. Crab Method
    a. Easier to maintain during approach, but requires a high degree of judgment in removing it right before touchdown
    b. How it Works
      - The pilot establishes a crab into the wind so that the airplane's ground track remains aligned with the centerline of the runway
      - Just prior to touchdown the longitudinal axis is aligned with the runway to avoid a sideward touchdown
    c. Not recommended
  ii. Sideslip (wing-low) Method (shown to the right)
    a. Recommended method

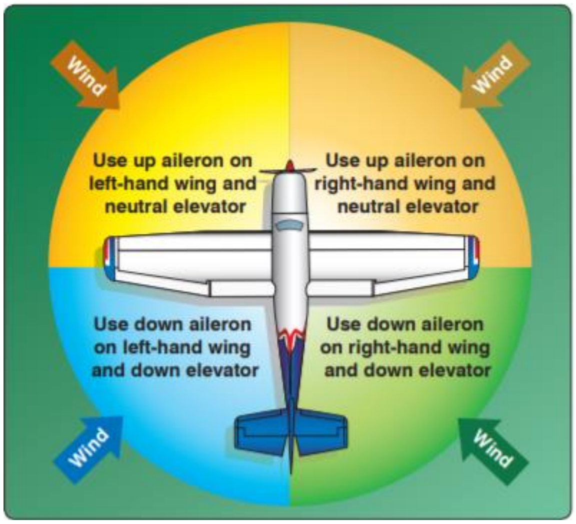
D. Final Approach
  i. Sideslip (Wing-Low)
    a. Align the airplane's heading with the centerline
      - Note rate and direction of drift
    b. Promptly apply drift correction
      - Lower the upwind wing
        a Amount of lowering depends on the drift
    c. When the wing is lowered, the plane turns that direction
      - To compensate for the turn, simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane aligned with the runway
      - The airplane will be side slipping into the wind just enough so that the flight path and ground track are aligned with the runway
    d. Changes in the crosswind are corrected for accordingly
      - Drift is controlled with aileron, and heading with rudder
        a Use ailerons to keep the airplane over the extended runway centerline
        b Use rudder to keep the longitudinal axis aligned with the runway centerline
    e. Strong Crosswind
      - To correct for a strong crosswind, the slip is increased by lowering the wing into the wind
        a To compensate for the additional bank, additional rudder is applied to keep the longitudinal axis of the airplane aligned with the runway centerline
        b At some point, there will not be insufficient rudder available to overcome the turning tendency caused by the steepened bank
          1. If the bank required is such that full opposite rudder does not prevent a turn, the wind is too strong to safely land the airplane on that runway, in those conditions, the pilot should find a more suitable runway
          2. At this point the wind has exceeded the airplane's crosswind performance capabilities
            a. Always be aware of the airplane's crosswind limitations
    f. Maintain a stabilized approach
      - Same as a normal approach, except with the added sideslip
      - Because you are in a slip, drag is increased requiring more power to maintain a given descent rate



- a Pitch for airspeed & power for altitude

ii. Roundout
  a. Like a normal landing approach, but the crosswind correction is maintained/continued to prevent drift
    - Don't level the wings. Keep the upwind wing down throughout the roundout
      - a Leveling the wings will result in drifting and side loading the gear
  b. Gradually increase aileron and rudder to maintain drift correction as the plane slows

iii. Touchdown
  a. The touchdown should be made on the upwind main wheel first
    - Continue to maintain the crosswind corrections to prevent drift
    - During gusty or high wind conditions, prompt adjustments are necessary to prevent drift during touchdown
  b. As momentum decreases, the downwind main wheel will settle onto the runway, then the nosewheel
    - Nose-wheel steering interconnected with the rudder: Nosewheel will not be aligned with the runway because rudder is being held for the crosswind correction
      - a To prevent swerving, rudder pressure must be relaxed as the nose wheel touches down



iv. After Landing Roll
  a. Maintain directional with rudder or nose-wheel steering, keep the upwind wing from rising with aileron
  b. Rudders & Directional Control
    - With the main wheels acting as a pivot point, and a greater surface area exposed to the crosswind behind that pivot point, the plane tends to point or weathervane into the wind
  c. Ailerons & Wings Level
    - As the plane slows, increase aileron into the wind
      - a Keeps upwind wing from rising
    - Coming to a stop, aileron should fully into the wind

E. Common Errors — AI.VII.B.K5
  i. Attempted landing in crosswinds that exceed the airplane's maximum demonstrated crosswind component
  ii. Undershooting or overshooting the turn from base leg to final approach
  iii. Inadequate compensation for wind drift on final approach
  iv. Unstable approach
  v. Excessive sink rate or too low an airspeed from increased drag and reduced vertical lift during sideslip
  vi. Failure to touch down with the longitudinal axis aligned with the runway
  vii. Touching down while drifting
  viii. Excessive airspeed on touchdown

- ix. Failure to apply appropriate flight control inputs during rollout
- x. Failure to maintain direction control on rollout
- xi. Excessive braking
- xii. Loss of aircraft control

RM: **Hazards & Emergencies**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

- A. VII. RM Concepts – Rejected Landing & Go-Around AI.VII.B.R3a
- B. VII. RM Concepts – Land and Hold Short Operations (LAHSO) AI.VII.B.R3b
- C. VII. RM Concepts – Wind Shear AI.VII.B.R2b
- D. VII. RM Concepts – Wake Turbulence AI.VII.B.R2d
- E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.B.R6
- F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.B.R5
- G. VII. RM Concepts – Collision Hazards AI.VII.B.R4

Conclusion:

Brief review of the main points

As simple and basic a procedure as this seems to be, a lot goes into a well-executed approach. Putting all of these parts together over time will result in a much more confident, safe, and skilled pilot. The fine nuances of a stabilized, well-planned approach are well worth the result the first time you 'grease' a landing.

Private Pilot ACS Skills Standards

1. Maintain approach airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
2. Touch down at a proper pitch attitude, within 400 feet beyond or on the specified point, with no side drift, and with the aircraft's longitudinal axis aligned with and over the runway center/landing path.

Commercial Pilot ACS Skills Standards

1. Maintain approach airspeed, or in its absence, not more than 1.3 V_{SO}, ± 5 knots with gust factor applied.
2. Touch down at a proper pitch attitude, within 200 feet beyond or on the specified point, with no side drift, and with the aircraft's longitudinal axis aligned with and over the runway center/landing path.

VII.C. Soft-Field Takeoff & Climb

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	To develop the understanding of the soft-field takeoff as well as the skills needed to perform the takeoff from a soft-field. The learner should be able to demonstrate the soft-field takeoff to ACS standards.
Key Elements	1. Constant back pressure 2. Transfer weight from the wheels to the wings 3. Stay in ground effect until reaching V_Y or V_X
Elements	1. Overview 2. Taxi 3. Takeoff Roll 4. Lift-Off 5. Initial Climb 6. Common Errors 7. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner can demonstrate the knowledge of, and has shown proficiency in, soft field takeoffs and climbs, with and without an obstacle, and without the assistance of a flight instructor. The learner must be able to maintain positive control of the airplane in ground effect until reaching the proper speed for climb out while demonstrating the proper use of checklists, traffic scan and safety procedures.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Have you ever got your car stuck off-roading? Why did it happen? So, what do we do when we have to takeoff in off-road conditions?

Overview

Review Objectives and Elements/Key ideas

What

A takeoff from a "soft" field. Just like it says in the name, we are attempting to takeoff from a soft, often uneven surface which could produce enough drag to prevent the airplane from reaching normal takeoff speeds.

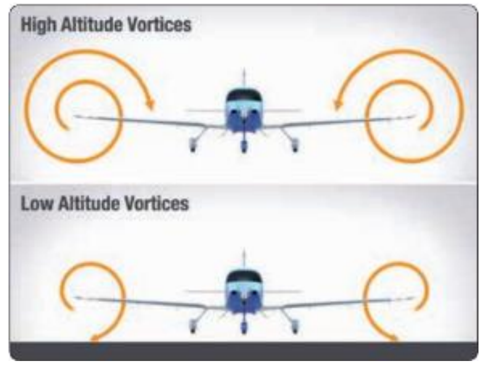
Why

Soft surfaces or long wet grass can reduce the aircraft's acceleration so much during the takeoff roll that adequate takeoff speed might not be attained if normal takeoff techniques were employed. As a maneuver, this will greatly improve your takeoffs, landings, and overall aircraft control.

How:

1. **Overview** AI.VII.C.K1
   A. Differences from a Normal Takeoff: AI.VII.C.K6
      i. Reduced ability to accelerate
         a. Taking off from a soft surface (sand, tall grass, snow, dirt, mud, etc.) reduces the ability to accelerate and may prevent the airplane from reaching adequate takeoff speed using normal takeoff techniques
      ii. Potentially hazardous terrain
         a. Even if the plane could accelerate on the soft-field, high speed over rough, uneven terrain presents its own challenges
            - Gear damage: Debris as well as the high stress associated with uneven terrain
            - Damage to the flaps (more applicable to a low wing airplane)
               a The longer the airplane stays on the ground, the more debris is thrown toward the flaps
            - Cartwheeling or flipping
               a If the nosewheel hit a hole during the takeoff run the results could be catastrophic, especially at high speeds
      iii. To minimize hazards, the goal is to get off the ground as quickly as possible, and accelerate to a safe climb speed in ground effect
         a. Accomplished by establishing a relatively high angle of attack as early as possible
         b. Once airborne, staying in ground effect requires a feel for the plane and fine control touch
            - Too much forward pressure could lead to ground contact
            - Not enough forward pressure could result in climbing out of ground effect at too low of an airspeed
               a Results in settling back to the runway, or a stall
   B. Ground Effect AI.VII.C.K5
      i. Associated with the reduction of induced drag
      ii. When close to the ground, the vertical component of the airflow around the wing is restricted by the ground
         a. Causes a reduction in wingtip vortices and a decrease in upwash and downwash
         b. Decreases induced drag

iii. Effects on Flight
   a. Amount of thrust required to produce lift is reduced
      - Plane can lift off at lower-than-normal speed
   b. Climbing out of ground effect, the power (thrust) required to sustain flight increases significantly
      - Normal airflow returns and induced drag increases
   c. If you climb before reaching normal takeoff speed the plane can sink back to the surface



C. The Basics
   i. Maintain back pressure
      a. Keep as much weight as possible off the nose to prevent it from getting stuck, or digging in
      b. Maintain back pressure during the taxi and takeoff roll
   ii. Keep the aircraft moving
      a. Stopping on a soft surface might bog the airplane down or get it completely stuck
      b. The pilot should maintain continuous motion with sufficient power while lining up for the takeoff roll
   iii. Do a wheelie down the runway
      a. Establish and maintain a relatively high angle of attack or nose-high pitch as early as possible
         - Nose will leave the ground prior to the mains. Adjust back pressure to keep the nose off the ground
      b. Transfer the airplane's weight rapidly as possible from the wheels to the wings
   iv. Accelerate in ground effect until reaching climb speed
      a. The airplane will become airborne prior to normal rotation speed, and well before a safe climb speed
         - Do not attempt to climb out of ground effect before reaching a safe climb speed (V_X or V_Y)
            a May result in settling back to the surface, not being able to climb even with full power, or a stall

D. RM: Runway Selection AI.VII.C.K2, AI.VII.C.R1
   i. Wind:
      a. Headwind decreases the required takeoff distance
         - Shorter runways can be used
         - More runway is available in the case that the airplane needs to be stopped
         - Reduces wear and stress on the landing gear
      b. Increased climb performance
      c. RM: Tailwind increases the required ground roll (RM: Effects of Tailwind) AI.VII.C.R2c
         - Requires the more distance to obtain the required airflow over the wings during takeoff
         - There are times a takeoff with a tail wind is necessary - POH: Reference any tailwind limitations
   ii. Aircraft Performance
      a. Atmospheric Pressure
         - Since air is a gas, it can be compressed or expanded, affecting density
         - Changes in air density affect performance - As density increases, performance increases & vice versa
      b. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
         - Density varies directly with pressure - As pressure increases, density increases and vice versa
         - Density varies inversely with temperature – As temp increases, density decreases and vice versa
         - Density varies inversely with altitude - As altitude increases, density decreases and vice versa
         - Density varies inversely with humidity – As humidity increases, density decreases and vice versa
      c. How it affects Performance
         - As the air becomes less dense, it reduces:
            a Power, since the engine takes in less air
            b Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
            c Lift, because the thin air exerts less force on the airfoils

iii. Runway Characteristics AI.VII.C.R2e
  a. Surface: More friction associated with softer surfaces – increases takeoff roll
  b. Gradient: Upsloping runway increases takeoff roll – reference the Chart Supplement for runway gradient
  c. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
  d. Available Distance: Runway length available for takeoff

iv. Performance Charts
  a. Take into account all of the above information, and more (weight, configuration, etc.)
  b. Reference takeoff & climb performance charts (generally, takeoff distance & takeoff climb)
    - Verify required distance and climb abilities are compatible with the runway/environment

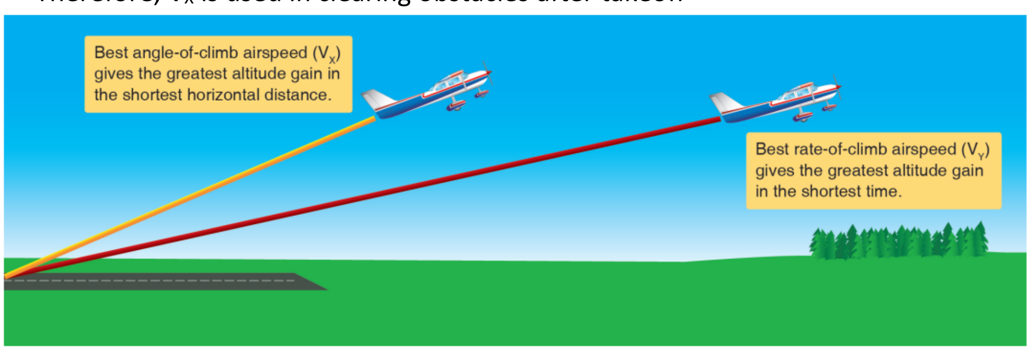
v. Pilot Capability
  a. Set and strictly adhere to personal minimums
  b. Ensure proficiency and safety

vi. Limitations
  a. Reference the POH for any applicable limitations

E. Best Angle versus Best Rate of Climb AI.VII.C.K3

i. Best Rate of Climb (V_Y)
  a. Performed at the airspeed producing the most altitude gain in the least time (max feet per minute)
    - Airspeed where the most excess *power* is available over that required for level flight
      a Power is the energy the engine produces
  b. As altitude increases, the airspeed for the best rate of climb decreases
  c. The best rate of climb speed + maximum power = the aircraft's maximum climb
    - Attempts to get more climb performance by increasing pitch results in a decreased rate of climb

ii. Best Angle of Climb (V_X)
  a. Performed at an airspeed that will produce the most altitude gain the shortest distance
    - Slower than V_Y
  b. Airspeed where the most excess t*hrust* is available over that required for level flight
    - Thrust is what propels the airplane (the displaced air as a result of the spinning propeller)
  c. As altitude increases, the airspeed for the best angle of climb increases
  d. Read Thrust vs Power (on medium.com) for a short article breaking down the two terms
  e. V_X will result in a steeper climb path, but will take longer to reach altitude than a climb at V_Y
    - Therefore, V_X is used in clearing obstacles after takeoff



F. Configuration AI.VII.C.K4

i. Reference the POH and Before Takeoff checklist

ii. *Takeoff flaps in DA20
  a. Configuration varies based on the aircraft and type of takeoff

2. Taxi

A. Keep the elevator fully aft for the entire taxi

i. This keeps as much weight as possible off the main wheel keeping it from getting stuck or bogged down

B. More power is necessary due to the increased ground friction/drag
   i. This also increases control effectiveness due to larger displacement of air
C. Keep turns shallow and don't stop
   i. Stopping on a soft surface, such as mud or snow, might bog the airplane down; therefore, it should be kept in continuous motion with sufficient power while lining up for the takeoff roll
D. Airport Procedures
   i. Assuming uncontrolled, make normal traffic calls when taxiing to alert others of your position/intentions
      a. Use other aircraft radio calls to build a mental picture of the traffic and how they may affect you
   ii. At a controlled airport, follow the tower's instructions
   iii. Before taxiing onto the runway visually clear the area
      a. Check the final approach and the rest of runway for traffic, or obstructions
      b. Never taxi out with another plane on final approach
      c. Be alert to any debris, animals, etc. that may be on the runway prior to attempting takeoff

3. Takeoff Roll

A. Continue to maintain back elevator pressure and aircraft movement
   i. Don't let the nose wheel settle or the aircraft come to a stop
B. RM: Apply crosswind corrections (the same as a normal takeoff) AI.VII.C.R2a
   i. Full aileron into the wind at the beginning of the takeoff roll
C. While aligning the aircraft with the takeoff path, takeoff power is accelerated smoothly and rapidly
   i. Don't stop
   ii. Left turning tendencies: Apply right rudder to counter AI.VII.C.K7
   iii. Check the engine/instruments – "Gauges green," "Airspeed alive"
   iv. Anticipate a slow acceleration due to the additional drag associated with a soft-field
   v. CE: Improper use of controls during a short-field takeoff
D. Back elevator pressure is initially held full aft
   i. As the plane accelerates, and the nose lifts off the ground the elevator pressure is relaxed
      a. *Half back pressure in DA20 to continue the takeoff roll with the nose off the ground
      b. Full back pressure during acceleration would result in the tail striking the ground
   ii. *Site Picture: Cowling on the horizon
      a. Approximately 5-6º of pitch
   iii. With the nose-high attitude throughout the takeoff run, the wings will increasingly relieve the wheels of the airplane's weight as speed increases and lift develops, minimizing drag caused by the soft-field
   iv. The airplane will effectively fly itself off the ground at a speed slower than the normal rotation speed

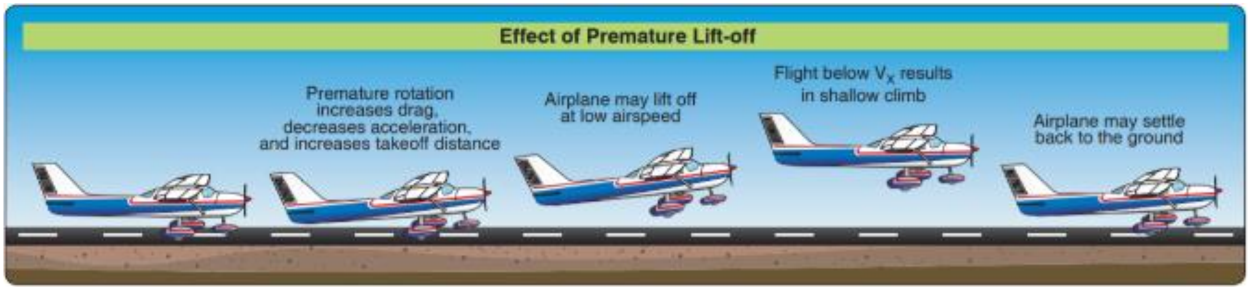
4. Lift-Off

A. Once airborne, gently lower the nose to allow acceleration to V_X or V_Y in ground effect
   i. to V_Y for a normal climb, V_X if an obstacle must be cleared
   ii. Remain within ½ wingspan of the ground (ground effect is most effective here)
   iii. Abrupt/excessive control movements could put the aircraft back into the ground (possibly nose first)
B. Site Picture: As airspeed/lift increase, point the nose down, toward the runway, to stay in ground effect
   i. Forward pressure is required to stay in ground effect
      a. Low to the ground with forward pressure & the nose pointing down can be uncomfortable to a new pilot
   ii. The airplane must remain in ground effect until at least V_X is reached

a. May settle back onto the surface, may not be able to climb further even with full power, or may stall

5. Initial Climb

A. After a positive rate of climb is established, and the plane has accelerated to V_X or V_Y, climb out as normal



i. Retract the gear and flaps as normal

ii. Soft field runways are often short field runways (V_X may often be necessary)

a. If climbing out to avoid an obstacle, the climb out is performed at V_X until the obstacle is cleared

b. After clearing the obstacle, pitch is adjusted to V_Y and the power may be set to the normal climb setting

- Retract the gear and flaps as appropriate for obstacle clearance and performance

iii. If departing from a wet/slushy airstrip, the gear should not be retracted immediately, allowing it to air dry

a. If cold, cycle multiple times to avoid freezing

b. If departing from a wet/slushy airstrip with an obstacle to clear, retract the gear when a positive rate of climb is established to achieve the desired performance, if required by the manufacturer's guidelines

- If necessary to prevent freezing, lower and/or cycle the gear once clear of the obstacle
- Follow the manufacturer's guidelines

B. Complete the Climb Checklist

i. The non-standard procedures associated with a soft-field takeoff could distract the pilot leading to missed steps. Always back yourself up with the checklist!

6. Common Errors AI.VII.C.K8

A. Failure to review AFM/POH and performance charts prior to takeoff.

B. Failure to adequately clear the area.

C. Insufficient back-elevator pressure during initial takeoff roll resulting in inadequate AOA.

D. Failure to cross-check engine instruments for indications of proper operation after applying power.

E. Poor directional control.

F. Climbing too high after lift-off and not leveling off low enough to maintain ground effect attitude.

G. Abrupt and/or excessive elevator control while attempting to level off and accelerate after liftoff.

H. Allowing the airplane to "mush" or settle resulting in an inadvertent touchdown after lift-off.

I. Attempting to climb out of ground effect area before attaining sufficient climb speed.

J. Failure to anticipate an increase in pitch attitude as the airplane climbs out of ground effect.

7. RM: Hazards & Emergencies

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Takeoff AI.VII.C.R3a

B. VII. RM Concepts – Engine Failure AI.VII.C.R3b
C. VII. RM Concepts – Wind Shear AI.VII.C.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.C.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.C.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.C.R5
G. VII. RM Concepts – Collision Hazards AI.VII.C.R4

Conclusion:
Brief review of the main points
Anytime we are taking off from a soft field runway we need to get the weight off the wheels and onto the wings as quickly as possible. This reduces the drag associated with a soft-field and allows the airplane to accelerate to a safe speed before climbing out. Without these procedures it's very possible the plane would never reach takeoff speed.

Private Pilot ACS Skills Standards
1. Lift off at the lowest possible airspeed and remain in ground effect while accelerating to V_X or V_Y, as appropriate.
2. Establish a pitch attitude for V_X or V_Y, as appropriate, and maintain selected airspeed +10/-5 knots during the climb.
3. Maintain V_X or V_Y, as appropriate, +10/-5 knots to a safe maneuvering altitude.

Commercial Pilot ACS Skills Standards
1. Lift off at the lowest possible airspeed and remain in ground effect while accelerating to V_X or V_Y, as appropriate.
2. Establish a pitch attitude for V_X or V_Y, as appropriate, and maintain selected airspeed ± 5 knots during the climb.
3. Maintain V_X or V_Y, as appropriate, ± 5 knots to a safe maneuvering altitude.

VII.D. Soft-Field Approach & Landing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives

The learner has the knowledge and ability to perform a soft field approach and landing as necessary based on the ACS with and without a crosswind.

Key Elements

1. Extend the approach in ground effect
2. Transfer weight from wings to wheels
3. Maintain Back Pressure

Elements

1. Objective
2. Runway Selection
3. Approach
4. Landing
5. After Landing Roll & Taxi
6. Common Errors
7. Hazards & Emergencies

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment

1. White board and markers
2. References
3. Model Airplane

IP's Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP's Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards

The learner can demonstrate knowledge of and has shown proficiency in Soft Field approaches and landings, without the assistance of a flight instructor. The learner can judge when to begin the flare, when to add power to the flare and can correct any misjudgments. Finally, the learner understands when to go-around and demonstrates the proper use of checklists, traffic scan and pertinent safety procedures.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

How awesome would it be, once you get your private pilot license, to take a flying adventure and land in the wilderness or on a remote island, in the middle of nowhere using a dirt or sand strip?

Overview

Review Objectives and Elements/Key ideas

What

Landing on fields that are rough or have soft surfaces, such as snow, sand, mud, or tall grass

Why AI.VII.D.K1

It is important to learn to land on soft field runways to ensure a safe landing. A normal landing on a runway like this could result in damage to the gear or the entire plane. By learning to safely set a plane down on different surfaces the pilot has many more available landing fields at his or her disposal. And, in the case of an emergency landing, this maneuver will be very important in making a safe landing.

How:

1. **Objective**
   A. To touchdown as smoothly as possible and at the slowest possible landing speed
      i. The pilot must control the airplane in a manner that the wings support the weight of the plane as long as practical to minimize drag and the stresses imposed on the landing gear by the rough or soft surface
2. **Runway Selection** AI.VII.D.K3, AI.VII.D.R1
   A. Wind
      i. Headwind
         a. Decreases groundspeed and therefore landing distance
         b. Reduced groundspeed requires a slower rate of descent on final
      ii. RM: Tailwind AI.VII.D.R2c
         a. Increases groundspeed and therefore landing distance
         b. Increased groundspeed requires a higher rate of descent on final
      iii. RM: Ensure any crosswind is within limits (personal & POH) (RM: Effects of crosswind) AI.VII.D.R2a
   B. Aircraft Performance
      i. Atmospheric Pressure
         a. Since air is a gas, it can be compressed or expanded, affecting density
         b. Changes in air density affect performance - As density increases, performance increases & vice versa
      ii. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
         a. Density varies directly with pressure - As pressure increases, density increases and vice versa
         b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
         c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
         d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
      iii. How it affects Performance
         a. As the air becomes less dense, it reduces:
            - Power, since the engine takes in less air
            - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)

- Lift, because the thin air exerts less force on the airfoils

b. Density Altitude & Landing
- Affects power requirements on approach & climb capability in the case of a go-around
- Higher density altitude = higher true airspeed which increases the landing roll

C. RM: Runway Characteristics AI.VII.D.R2e
 i. Surface: More friction associated with softer surfaces – decreases landing roll
 ii. Gradient: Down sloping runway increases landing roll – reference the Chart Supplement for runway gradient
 iii. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
 iv. Available Distance: Runway length available for landing

D. Performance Charts
 i. Take into account all of the above information, and more (weight, configuration, etc.)
 ii. Reference landing & climb performance charts (generally, landing distance/performance & climb performance or balked landing climb charts)
  a. Verify required distance and climb abilities are compatible with the runway/environment

E. Pilot Capability
 i. Set and strictly adhere to personal minimums (runway length/width, winds, weather, etc.)
 ii. Ensure proficiency and safety

F. Limitations are found in Chap 2 of the POH
 i. Applicable limitations can include maximum weights, crosswind/tailwind limitations, minimum runway length/width, flap/gear extension speeds, stall speeds, center of gravity limitations, etc.

3. Approach

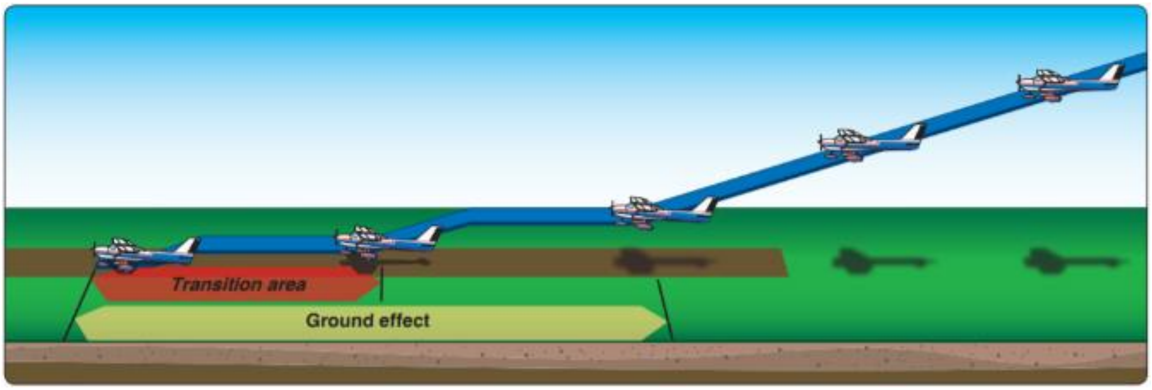
A. Like a normal approach, except the plane is held 1 to 2' off the surface in ground effect as long as possible to let the wheels to gently touch down at minimum speed – Small amount of power is used to cushion touchdown

B. Procedures
 i. Perform the before landing checklist and configure on downwind
 ii. Configure as directed by the POH – generally with landing flaps
  a. Flaps will aid in touching down at minimum speed and are recommended whenever practical
  b. In low-wing airplanes the flaps may suffer damage from mud, stones, slush, etc.

C. Maintain a Stabilized Approach AI.VII.D.K2
 i. Establish the final approach speed
  a. *Maintain 65 knots – normal approach speed
   a *Unless it's a short field landing, then 55 knots (Soft-field runways are often also short-field)
  - Unless obstacles are present in the approach path, there is no reason for a steep angle of descent
   a A steep rate of descent would make it more difficult for a gentle touchdown
  b. Higher approach speeds may result in excessive floating in ground effect which can make a smooth, controlled touchdown even more difficult
 ii. Trim the plane for the descent
  a. Adjust pitch and power as necessary to remain stabilized
 iii. Establish and maintain an aim point in front of your intended touchdown area
  a. Touchdown area should be free of obstructions, as smooth/flat as possible, with distance to stop safely
  b. Due to the longer float, aim further in front of the landing point than for a normal approach
 iv. Throughout the approach, one hand should be kept on the power lever as often as possible
  a. Of course, some duties require your hand to be moved (configuring, etc.)
  b. Because power is maintained through the touchdown, always be ready to correct power, or go-around
  c. At any time before the airplane is on the ground, and the weight is being supported by the wheels, the pilot should be able to apply full power and perform a safe takeoff (obstacles/field length permitting)

D. Maintain Coordination
 i. Use rudder to maintain coordination, especially when turning base to final

ii. No more than 30º of bank
iii. A sideslip in the case of a crosswind is the exception to the rule
E. Maintain a Precise Ground Track
i. RM: Account for the effect of wind (RM: Effects of crosswind) AI.VII.D.K4, AI.VII.D.R2a
a. Crab as necessary to maintain a proper downwind leg, base leg, and final approach
b. Sideslip into the wind to maintain the extended centerline



4. Landing
A. The major differences between a soft-field and a normal landing:
i. The airplane is held 1 to 2' above the ground, in ground effect as long as possible
a. The airplane should be flown onto the ground with the weight fully supported by the wings
- Permits a gradual dissipation of forward speed to allow the wheels to touch down gently at minimum speed
- Also minimizes the nose-over forces that affect the airplane at the moment of touchdown

ii. A small amount of power is used during touchdown to cushion the landing
a. Use the same technique as a normal landing, but with partial power during the roundout and touchdown to extend the approach and allow for a gentle touchdown
iii. After main wheel touchdown, hold sufficient back pressure to keep the nose wheel off the surface
a. This helps to prevent the nosewheel digging into the soft surface, and/or getting stuck
b. Worst-case scenario, it prevents the airplane from cartwheeling after striking the uneven, soft surface
B. Touchdown
i. Continue to maintain one hand on the throttle lever
a. At any time during this transition phase, before the weight is being supported by the wheels, the pilot should be able to apply full power and perform a safe takeoff (obstacles and field length permitting)
ii. Increase power slightly just prior to touchdown to cushion landing & slowly transfer weight to the wheels
a. The addition of power will vary based on aircraft and the terrain
- Ex: Tall thick grass (more drag, therefore more power) versus packed dirt (less drag, less power)

iii. Touchdown should be made at the lowest possible airspeed in a nose-high pitch attitude
a. As speed decreases, increase back pressure to stay in ground effect and touchdown as gently as possible
b. A firm touchdown is not desired – could be hazardous on a rough or uneven surface
iv. When the main wheels touch ground, maintain back pressure to keep the nose wheel off the surface
a. *Site Picture: Hold the cowling on the horizon to keep the nose wheel off the ground
b. As the aircraft slows, increase elevator back pressure to keep the nose wheel off the ground
- Back elevator and engine power can control the rate the weight is transferred to the wheels

c. Don't close the throttle too soon after touchdown
- Results in the nose wheel touching down and early transfer of weight to the wheels at higher speeds
  a Can damage the nosewheel or the aircraft

v. Maintain directional control with the rudder, while maintaining crosswind correction with the ailerons

        a. As the aircraft slows and the controls become less effective, increase the crosswind correction
    vi. The use of brakes is not needed and should be avoided as this may tend to impose a heavy load on the nose gear due to premature or hard contact with the landing surface, causing the nose wheel to dig in
        a. The soft surface provides sufficient reduction in the airplane's forward speed
        b. Power often needs to be increased to keep the plane moving and from becoming stuck
    vii. Once slowed, safe and under control, the pilot should gently lower the nose wheel to the surface
        a. A slight addition of power usually will aid in easing the nose wheel down
    viii. RM: Landing in a Crosswind (RM: Effects of crosswind) AI.VII.D.K4, AI.VII.D.R2a
        a. Touchdown gently in a sideslip, upwind wheel first, with the longitudinal axis aligned with the centerline
            - Upwind main wheel followed by the downwind main wheel
        b. Use back pressure to keep the nose wheel off the ground
        c. Maintain crosswind controls during the landing increase aileron pressure as the aircraft slows
        d. Be cautious, if control is in doubt, execute a go around

5. After Landing Roll & Taxi

A. Continue to maintain full aft elevator pressure, as well as wind correction
B. Maintain directional control through the rudders
    i. Directional control will likely be more difficult on a soft field than a paved runway and taxiway
    ii. Use rudder, and avoid using differential braking to control the airplane on the ground
C. As mentioned above, the use of brakes is not needed and should be avoided
    i. Braking is normally accomplished through surface friction with the ground
        a. The pilot will often need to increase power to keep the airplane moving and avoid becoming stuck
D. Maintain enough speed to prevent becoming bogged down
    i. Again, an increase in power may be necessary to keep the plane moving
E. Retract the flaps after the landing roll is completed
    i. It is generally inadvisable to retract flaps during the after-landing roll because the need for flap retraction is less important than the need for total concentration on maintaining full control of the airplane
    ii. Retracting the flaps also puts more weight onto the wheels
F. Perform the After-Landing Checklist once parked

6. Common Errors AI.VII.D.K5

A. Excessive descent rate on final approach.
B. Excessive airspeed on final approach.
C. Unstable approach.
D. Round out too high above the runway surface.
E. Poor power management during round out and touchdown.
F. Hard touchdown.
G. Inadequate control of the airplane weight transfer from wings to wheels after touchdown.
H. Allowing the nose-wheel to "fall" to the runway after touchdown rather than controlling its descent.

7. RM: Hazards & Emergencies

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Landing & Go-Around AI.VII.D.R3a
B. VII. RM Concepts – Land and Hold Short Operations (LAHSO) AI.VII.D.R3b
C. VII. RM Concepts – Wind Shear AI.VII.D.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.D.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.D.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.D.R5
G. VII. RM Concepts – Collision Hazards AI.VII.D.R4

Procedures for a soft-field landing AI.VII.D.K1

The lesson as a whole is a discussion of soft-field procedures

Conclusion:

Brief review of the main points

A soft field landing is very similar to a normal landing except that our main goal is to transfer the weight from the wings to wheels as gently as possible. When doing this it is also important to hold the nose wheel off the ground, and then slowly and gently bring it to the surface.

Private Pilot ACS Skills Standards

1. Maintain published speed, or in its absence not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.

Commercial Pilot ACS Skills Standards

1. Maintain published speed, or in its absence not more than 1.3 V_{SO}, ±5 knots with gust factor applied

VII.E. Short-Field Takeoff & Maximum Performance Climb

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives — The learner should develop knowledge of the elements related to short field takeoffs and maximum performance climbs. The learner can demonstrate a short field takeoff and climb as prescribed in the necessary ACS.

Key Elements
1. Use the Entire Runway
2. Maximum Performance Climb at V_X
3. Focus Outside the Airplane

Elements
1. Best Rate versus Best Angle of Climb
2. Pre-Takeoff
3. Takeoff Roll
4. Lift-Off
5. Maximum Performance Climb
6. Common Errors
7. Hazards & Emergencies

Schedule
1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment
1. White board and markers
2. References

IP's Actions
1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP's Actions
1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards — The learner shows the ability to execute a proper short-field takeoff and climb by using the entire runway, after rotation pitching immediately for V_X until clear of obstacles, then pitching for V_Y.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Maximum Performance Takeoff and Climb… this is the mother of all takeoffs, where we put the airplane at its limits to obtain the most performance out of the airplane.

Overview

Review Objectives and Elements/Key ideas

What

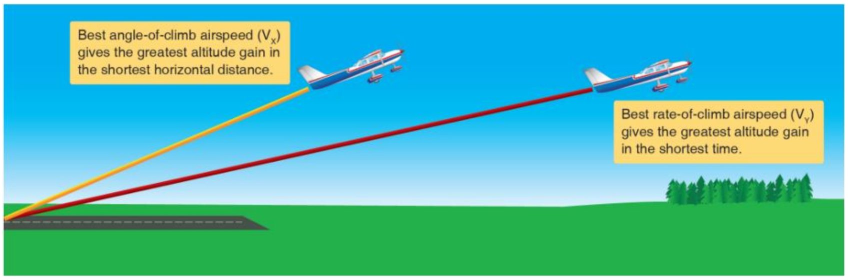
Takeoffs and climbs from fields where the takeoff area is short, or the available takeoff area is restricted by obstructions requiring the pilot to operate the airplane at the limit of its takeoff performance capabilities.

Why AI.VII.E.K1

Short Field Takeoffs develop the pilot's ability to operate the airplane at its maximum takeoff performance capabilities. This develops a better feel for the plane and results in improved takeoffs and airplane control and provides the pilot with the ability to use airports that they otherwise could not.

How:

1. **Best Rate versus Best Angle of Climb** AI.VII.E.K3
   A. Best Rate of Climb (V_Y)
      i. Airspeed producing the most altitude gain in the least time (max feet per minute)
         a. Airspeed where the most excess *power* is available over that required for level flight
            - Power is the energy the engine produces
      ii. As altitude increases, the airspeed for the best rate of climb decreases
   B. V_X Best Rate of Climb
      i. To accomplish this takeoff safely, a pilot must have knowledge of V_X
      ii. Speed which will provide the greatest gain in altitude for a given distance over the ground
         a. Usually slightly less than V_Y and used to clear obstacles
         b. Results in a steeper climb path, but will take longer to reach altitude than a climb at V_Y



      iii. Airspeed where the most excess t*hrust* is available over that required for level flight
         a. Thrust is what propels the airplane (the displaced air due to the spinning propeller)
         b. As altitude increases, the airspeed for the best angle of climb increases
      iv. *V_X is 58 knots (DA20)
      v. Small deviations (5 knots) in some airplanes will result in a significant reduction in climb performance
         a. Precise control of airspeed has an important bearing on the execution/safety of the maneuver
2. **Pre-Takeoff**
   A. RM: Runway Selection AI.VII.E.K2, AI.VII.E.R1
      i. Wind:
         a. Headwind decreases the required takeoff distance

- Shorter runways can be used
- More runway is available in the case that the airplane needs to be stopped
- Reduces wear and stress on the landing gear

b. Increased climb performance

c. RM: Tailwind increases the required ground roll (RM: Effects of Tailwind) AI.VII.E.R2c

- Requires the more distance to obtain the required airflow over the wings during takeoff
- There are times a takeoff with a tail wind is necessary - POH: Reference any tailwind limitations

ii. Aircraft Performance

a. Atmospheric Pressure

- Since air is a gas, it can be compressed or expanded, affecting density
- Changes in air density affect performance - As density increases, performance increases & vice versa

b. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity

- Density varies directly with pressure - As pressure increases, density increases and vice versa
- Density varies inversely with temperature – As temp increases, density decreases and vice versa
- Density varies inversely with altitude - As altitude increases, density decreases and vice versa
- Density varies inversely with humidity – As humidity increases, density decreases and vice versa

c. How it affects Performance

- As the air becomes less dense, it reduces:
  - a Power, since the engine takes in less air
  - b Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
  - c Lift, because the thin air exerts less force on the airfoils

iii. Runway Characteristics AI.VII.E.R2e

a. Surface: More friction associated with softer surfaces – increases takeoff roll

b. Gradient: Upsloping runway increases takeoff roll – reference the Chart Supplement for runway gradient

c. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness

d. Available Distance: Runway length available for takeoff

iv. Performance Charts

a. Take into account all of the above information, and more (weight, configuration, etc.)

b. Reference takeoff & climb performance charts (generally, takeoff distance & takeoff climb)

- Verify required distance and climb abilities are compatible with the runway/environment

v. Pilot Capability

a. Set and strictly adhere to personal minimums

b. Ensure proficiency and safety

vi. Limitations

a. Reference the POH for any applicable limitations

B. Configuration AI.VII.E.K4

i. Configure per the POH (*In the case of the DA20, the airplane should be configured for a normal takeoff)

3. Takeoff Roll AI.VII.E.K1

A. Start at the very beginning of the takeoff area. The field is short, don't waste any runway

i. Align the airplane with the runway centerline/intended takeoff path and come to a complete stop

ii. Apply crosswind correction as would be done in a normal takeoff AI.VII.E.R2a

a. Full aileron into the wind, reducing as the aircraft accelerates

b. Rudder to maintain centerline

B. Smoothly and continuously, without hesitation, advance the throttle to maximum power

i. It has not been established that setting max power with the brakes held results in a shorter takeoff run

a. Follow the manufacturer's procedures

ii. Check instruments/gauges and announce, "airspeed alive," & "engine gauges green," or abort the takeoff

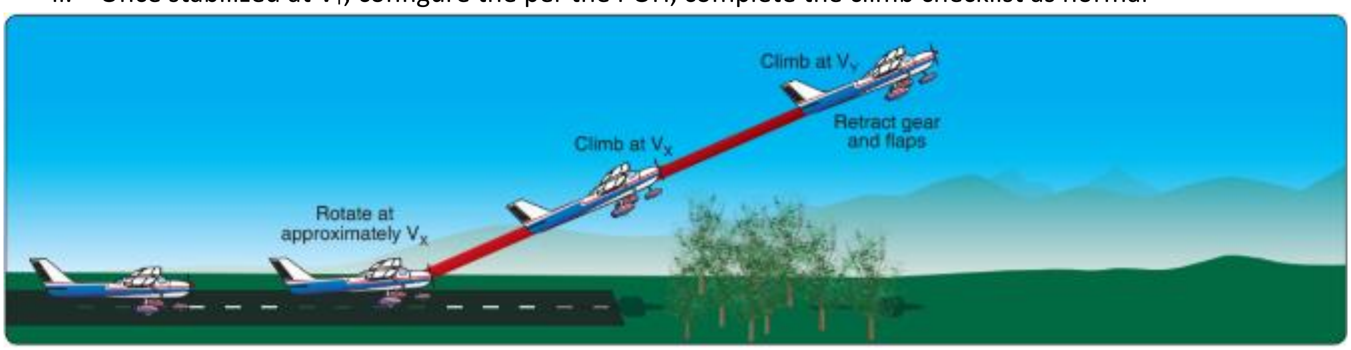
C. Maintain directional control with the rudders (left turning tendencies & weathervaning)
D. The airplane should be allowed to roll with full weight on the main wheels and accelerate to liftoff speed
  i. *Short Field V_R – 52 knots
  ii. Adjust pitch attitude/AOA to attain minimum drag and maximum acceleration
    a. This involves little use of the elevator (neutral position) since the plane is already in a low drag attitude

4. Lift-Off AI.VII.E.K1

A. *Smoothly and firmly rotate the airplane at V_R (52 knots) to the pitch attitude that will result V_X climb
  i. Use outside references and pitch on the attitude indicator to maintain the correct attitude
    a. *Approximately 12° nose up (slightly steeper than a normal takeoff)
B. In the case the airplane lifts off prior to V_R, allow the airplane to accelerate in ground effect to V_X
  i. Similar to soft-field takeoff – hold the plane in ground effect, with the wheels just clear of the runway
    a. Preferable to holding the plane on the ground with forward pressure
      - Results in excessive nosewheel pressure & wheel barrowing (reduces acceleration/performance)
C. Do not intentionally raise the nose prior to V_R, this will increase drag and prolong the roll
  i. An early lift-off/too steep climb may result in settling on the runway or a collision with the obstacle
    a. if the plane remains airborne, the initial climb will be flat and the climb is severely degraded
D. Once airborne, a wings level climb should be maintained at V_X until obstacles have been cleared
  i. Since the airplane accelerates more rapidly after liftoff, more back pressure is required to hold airspeed
    a. Airspeed is increasing rapidly; therefore, pitch will have to be increased to maintain V_X
  ii. Remove crosswind corrections and crab into the wind AI.VII.E.R2a

5. Maximum Performance Climb AI.VII.E.K1

A. Climb out at V_X until clear of obstacles
  i. Maintain visual references, occasionally glance at the attitude and airspeed indicators to check pitch and V_X
B. Configuration is not changed until clear of obstacles (unless recommended by the manufacturer)
  i. The pilot should not be heads down until clear of the obstacle
C. *Once clear of obstacles pitch for V_Y (65 knots)
  i. Visually – Normal takeoff climb picture
  ii. Once stabilized at V_Y, configure the per the POH, complete the climb checklist as normal



6. Common Errors AI.VII.E.K5

A. Failure to review AFM/POH and performance charts prior to takeoff.
B. Failure to adequately clear the area.
C. Failure to utilize all available runway/takeoff area.
D. Failure to have the airplane properly trimmed prior to takeoff.
E. Premature lift-off resulting in high drag.
F. Holding the airplane on the ground unnecessarily with excessive forward-elevator pressure.
G. Inadequate rotation resulting in excessive speed after lift-off.
H. Inability to attain/maintain V_X.
I. Fixation on the airspeed indicator during initial climb.

J. Premature retraction of landing gear and/or wing flaps.

7. RM: **Hazards & Emergencies**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Takeoff AI.VII.E.R3a
B. VII. RM Concepts – Engine Failure AI.VII.E.R3b
C. VII. RM Concepts – Wind Shear AI.VII.E.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.E.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.E.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.E.R5
G. VII. RM Concepts – Collision Hazards AI.VII.E.R4

Conclusion:

Brief review of the main points

The short-field takeoff and maximum performance climb is based on rotating and pitching directly for V_X. This allows for the greatest climb in the shortest distance, providing the most effective obstacle clearance.

Private Pilot ACS Skills Standards

1. Rotate and lift off at the recommended airspeed and accelerate to the obstacle clearance speed or V_X +10/-5 knots.
2. Maintain obstacle clearance speed, or V_X +10/-5 knots, until the obstacle is cleared, or until 50' above the surface.
3. Accelerate to V_Y, +10/-5 knots after clearing the obstacle or at 50' AGL if simulating an obstacle.
4. Maintain V_Y +10/-5 knots to a safe maneuvering altitude.

Commercial Pilot ACS Skills Standards

1. Rotate and lift off at the recommended airspeed and accelerate to the obstacle clearance airspeed or V_X ±5 knots.
2. Maintain obstacle clearance airspeed or V_X ±5 knots until the obstacle is cleared or until 50' above the surface.
3. Accelerate to V_Y ± 5 knots after clearing the obstacle or at 50' AGL if simulating an obstacle.
4. Maintain V_Y ±5 knots to a safe maneuvering altitude.

VII.F. Short-Field Approach & Landing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of the elements related to a short-field approach and landing. The learner will understand the procedures involved and can properly execute them as prescribed in the ACS.
Key Elements	1. 4º Stabilized Approach 2. Region of Reverse Command 3. Minimal Float/Max Effective Braking
Elements	1. Short-Field Considerations 2. Configuration and Trim 3. Short Field Approach 4. Common Errors 5. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can perform a well-coordinated and stabilized short-field approach and landing as required in the ACS.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The short-field landing requires the airplane to be flown precisely while close to the ground to safely land in a confined area.

Overview

Review Objectives and Elements/Key ideas

What

Short-field approaches and landings require the use of procedures for approaches and landings at fields with a relatively short landing area or where an approach is made over obstacles limiting the available landing area. This low-speed type of power-on approach is closely related to flight at minimum controllable airspeeds.

Why AI.VII.F.K1

As in short-field takeoffs, a short field approach and landing is one of the most critical of the maximum performance operations. It requires that the pilot fly the airplane at one of its crucial performance capabilities, while close to the ground, to land safely within confined areas. To land on a short field, the pilot must have precise, positive control of the rate of descent and airspeed.

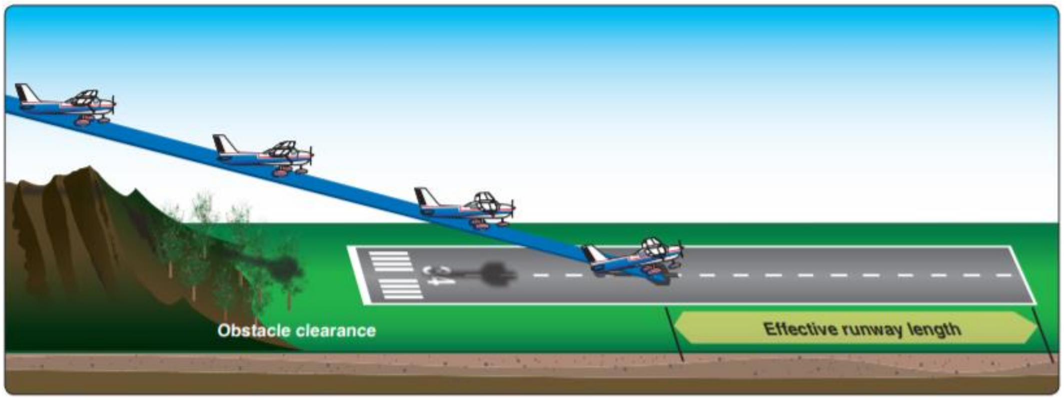
How:

1. **Short-Field Considerations**
   - A. Airplane Landing Performance and Limitations AI.VII.F.K3
     - i. Performance Section of the POH (Section 5)
       - a. *DA20: Landing distance over a 50' obstacle is about 1,360' and ground roll is about 665'
         - Varies based on weight, wind conditions, and other factors
       - b. Do not attempt to land if the landing performance is not adequate
       - c. Plan Ahead - Do not attempt to land on a short-field from which a takeoff cannot be made
         - The distance necessary to land is often less than the distance necessary to takeoff
       - d. Keep in mind that the runway surface will also affect the landing roll distance
         - Is this a paved runway, a soft field (dirt, grass), etc.?
     - ii. Limitations Section of the POH (Section 2) describes landing limitations
       - a. Be aware of what the airplane is and is not approved for
       - b. Also be aware of crosswind limitations
   - B. Obstructions and Hazards
     - i. The short field approach allows the pilot to land over obstacles limiting available landing area
     - ii. Be aware of the obstacles as well as other obstructions that might exist
       - a. What obstacles exist on the approach end of the runway?
       - b. How high are the obstacles? And does the height of the obstacle still allow for a safe landing?
         - What approach angle is required, what landing distance is required?
       - c. What obstacles could be a concern in the case of a go around?
       - d. Effects of wind
         - Tailwind? Crosswind? Varying winds due to the wind patterns over/around the obstruction?
         - Due to obstructions, there may only be one direction to takeoff and land
         - Monitor the wind conditions and ensure required performance

C. RM: Runway Selection AI.VII.F.K3, AI.VII.F.R1
   i. Wind
      a. Headwind
         - Decreases groundspeed and therefore landing distance
         - Reduced groundspeed requires a slower rate of descent on final
      b. RM: Tailwind AI.VII.F.R2c
         - Increases groundspeed and therefore landing distance
         - Increased groundspeed requires a higher rate of descent on final
   ii. RM: Ensure any crosswind is within limits (personal & POH) (RM: Effects of crosswind) AI.VII.F.R2a
   iii. Aircraft Performance
      a. Atmospheric Pressure
         - Since air is a gas, it can be compressed or expanded, affecting density
         - Changes in air density affect performance - As density increases, performance increases & vice versa
      b. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
         - Density varies directly with pressure - As pressure increases, density increases and vice versa
         - Density varies inversely with temperature – As temp increases, density decreases and vice versa
         - Density varies inversely with altitude - As altitude increases, density decreases and vice versa
         - Density varies inversely with humidity – As humidity increases, density decreases and vice versa
      c. How it affects Performance
         - As the air becomes less dense, it reduces:
            a Power, since the engine takes in less air
            b Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
            c Lift, because the thin air exerts less force on the airfoils
         - Density Altitude & Landing
            a Affects power requirements on approach & climb capability in the case of a go-around
            b Higher density altitude = higher true airspeed which increases the landing roll
   iv. RM: Runway Characteristics AI.VII.F.R2e
      a. Surface: More friction associated with softer surfaces – decreases landing roll
      b. Gradient: Down sloping runway increases landing roll – reference the Chart Supplement for runway gradient
      c. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
      d. Available Distance: Runway length available for landing
   v. Performance Charts
      a. Take into account all of the above information, and more (weight, configuration, etc.)
      b. Reference landing & climb performance charts (generally, landing distance/performance & climb performance or balked landing climb charts)
         - Verify required distance and climb abilities are compatible with the runway/environment
   vi. Pilot Capability
      a. Set and strictly adhere to personal minimums (runway length/width, winds, weather, etc.)
      b. Ensure proficiency and safety
   vii. Limitations (Chap 2 of the POH)
      a. Applicable limitations can include maximum weights, crosswind/tailwind limitations, minimum runway length/width, flap/gear extension speeds, stall speeds, center of gravity limitations, etc.

2. Configuration and Trim

A. Configure per the POH



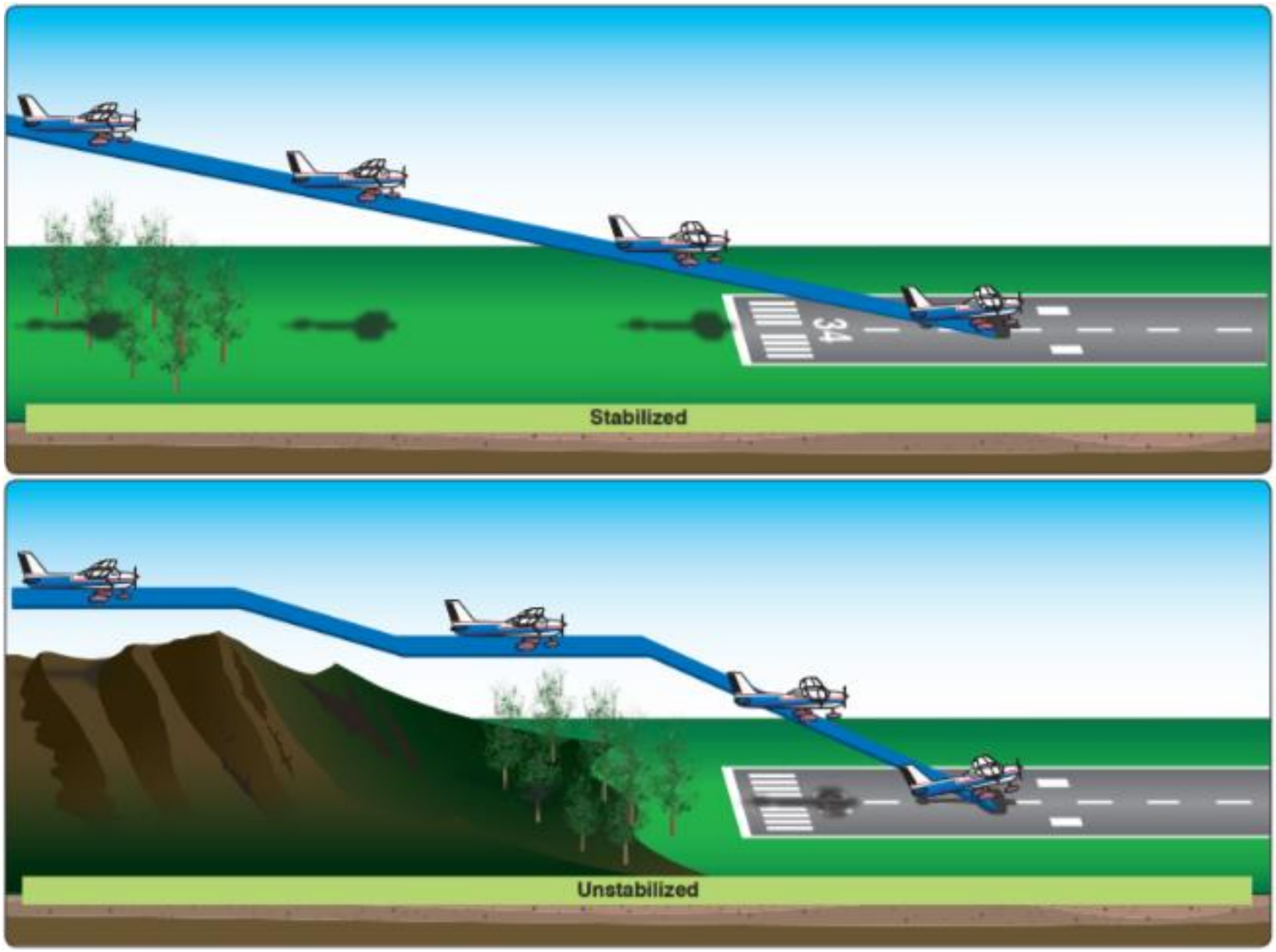
B. Final Approach is slower than normal to maintain a steeper glide path to clear any obstacles
  i. *4º Glide Path at 55 knots (DA20)
    a. *55 knots will provide an increased sink rate allowing for the steeper glide path
    b. As the airplane slows farther below L/D_{MAX}, the increase in drag increases the rate of descent
C. Technique: If possible, use a wider than normal pattern to be configured, trimmed, and stable early
D. Coordinated Flight Controls
  i. No more than 30º of bank and keep turns coordinated in the pattern
    a. Go around if overshooting final. Don't cross control the airplane!
  ii. Keep the airplane coordinated throughout the approach and landing
E. Trim as much as possible to relieve yourself of as much work as possible

3. Short-Field Approach AI.VII.F.K1

A. Downwind Leg
  i. At the midpoint of the downwind leg, complete the landing checklist
  ii. Select a Touchdown and Aim Point
    a. Touchdown Point (1,000' markers are good for training)
      - In real life, select a point that will both clear the obstacles and allow sufficient stopping distance
    b. *Aim Point (DA20: A good target is the beginning of the 2nd runway stripe prior to the 1,000' markers)
      - Aim point is closer to the touchdown point compared to a normal approach
        a Lower airspeed/higher descent rate = shorter float
        b DA20: approximately 400' - 450' prior to the touchdown point
      - Adjust the aim point based on wind
        a Stronger headwind results in a lower groundspeed and less float - aim closer to the point
          1. Opposite for a tailwind
  iii. Consider Establishing Go Around Points and Criteria
    a. Ex: If the approach is into a valley surrounded by mountains, the pilot may have to decide to go around by 500' AGL, any lower than that and the pilot is committed to landing due to the terrain
    b. The airlines and Air Force use "gates" to establish critical points in the approach at which if the pilot does not meet certain criteria, they will execute a go around
      - Ex: if the airplane is not configured for landing by 1,000', or if outside of specific parameters at 300' (airspeed, bank, approach path, etc.) the crew will go around
    c. GA pilots should apply the same techniques, especially in a short-field approach
      - Examples will vary by aircraft and situation, but could include:
        a 1,000' – configured for landing, on speed, and trimmed
        b 500' – Airspeed ±5 knots, bank less than 15º, centerline, on desired approach path
        c 250' – Airspeed ±5 knots, bank less than 15º, centerline, the desired approach path, crosswind corrections established

      - d Momentary deviations are acceptable, otherwise a go-around is executed
    - Monitors performance and provides a criteria-based standard (no guessing)
  - iv. *Abeam or slightly beyond the landing point, set power to 1500 RPM, extend takeoff flaps, pitch for 75 KIAS
  - v. The downwind leg can be extended to allow time to properly configure and trim the airplane
- B. Base Leg
  - i. Technique: Configure for landing
    - a. Preferred by some to allow more time to get stable
    - b. Another option is to wait until established on final before configuring for landing
    - c. *Extend the landing flaps and trim the airplane for 55 knots before turning final
      - Ensure a shallow, coordinated turn to final to avoid an unsafe situation
    - d. By the time you turn final the airplane should be in the landing configuration
- C. Final Approach
  - i. Configure, as required
  - ii. Usually started at least 500' AGL
    - a. Don't make a short approach over an obstacle if you don't have to
      - Give yourself time to ensure you're stabilized and can clear the obstacle comfortably
  - iii. Establish and maintain a 4° glide path
    - a. Higher and steeper approach
    - b. If you haven't already, extend the landing flaps and trim the airplane for approach speed
      - *The slower approach speed (55 knots) will result in an increased sink rate (4° glide path)
        - a Higher speeds will result in considerable floating before touchdown
      - *Trim the aircraft to maintain 55 knots
    - c. Double check the landing checklist
    - d. VASIs/PAPIs will indicate a high glide path
      - VASIs – Both bars White
      - PAPIs –4 White lights (Indicates above a 3.5° glide slope)
    - e. When practicing the approach/landing, an obstacle will be simulated at the approach end
      - The airplane should be approximately 100' AGL at the approach end to ensure clearance
  - iv. Maintaining a Stabilized Approach AI.VII.F.K2
    - a. The landing is in reality an accuracy approach to a spot landing – a stabilized approach is essential
    - b. Pitch for Airspeed, Power for Altitude
      - Below L/D_{MAX} – In the Region of Reverse Command
        - a *Maintain 55 knots and adjust power for a safe descent
      - Make small adjustments to keep the aim point in the same place on the windscreen
        - a Large adjustments lead to chasing the airspeed, pitch, and aim point
    - c. Aim Point Adjustments
      - A coordinated combination of pitch and power is required
        - a Done properly, very little change in pitch and power is necessary to make corrections
      - If obstacle clearance is excessive and touchdown will occur beyond the desired spot:
        - a Reduce power and lower pitch to maintain airspeed
        - b Once the aim point is back to the desired position on the windscreen, re-introduce the power, and adjust the pitch to establish the 4° approach path
      - If the descent angle does not ensure safe obstacle clearance:
        - a Increase power and pitch to maintain airspeed
        - b Once the aim point is back to the desired position, re-establish the 4° approach path

- DO NOT only pitch to gain altitude/avoid an obstacle
    - a Results in reduced airspeed and increased rate of descent. Uncorrected, this can lead to a stall



d. Always keep a hand on the throttle in case a go around/immediate power is needed (within reason)

v. Wind Correction AI.VII.F.K4

a. Headwind
- The airplane will be at a lower groundspeed and therefore take longer to make the final approach
    - a More power and a lower rate of descent is required
- Landing distance will be decreased

b. Tailwind
- The airplane will have a higher groundspeed and therefore spend less time on final approach
    - a Use less power and increase the rate of descent
- Landing distance will be increased

c. Crosswind AI.VII.F.R2a
- Crab into the wind until ready to establish a sideslip
- Sideslip: Aileron for drift, and rudder to align with the runway centerline

D. Roundout & Flare

i. The roundout must be judged accurately to avoid flying into the ground or stalling and sinking rapidly

ii. Minimum float should occur – the plane should settle relatively quickly onto the aiming point

a. A lack of float with sufficient control to touch down properly is verification the speed was correct

b. Do not try to hold the airplane off the ground and “grease” the landing

E. Touchdown
   i. Touchdown should occur at the minimum controllable airspeed with the airplane in the approximate pitch attitude that will result in a power off stall when the throttle is closed
      a. Closing before ready for touchdown may increase the descent and result in a hard touchdown
   ii. Stop within the shortest possible distance
      a. Hold the positive pitch attitude as long as the elevators are effective for aerodynamic braking
      b. Immediately upon touchdown and closing the throttle, brake to minimize the after-landing roll
         - *In the DA20, immediately retract the flaps to the 'Cruise' setting and apply max effective braking
            a Retracting flaps decreases transfers weight from the wings to wheels for more effective braking
            b Max Effective Braking - Braking to the point just prior to skidding the tires
   iii. Directional Control
      a. During and after landing, maintain the required crosswind corrections
         - As the airplane slows, increase the crosswind corrections as necessary
      b. Use rudder pressure to maintain the centerline as well as directional control
   iv. Crosswind AI.VII.F.R2a
      a. Use sideslip crosswind procedures, landing with the longitudinal axis aligned with the centerline

4. Common Errors AI.VII.F.K5

A. A final approach that necessitates an overly steep approach and high sink rate.
B. Unstable approach.
C. Undue delay in initiating glide path corrections.
D. Too low an airspeed on final resulting in inability to flare properly and landing hard.
E. Too high an airspeed resulting in floating on round out.
F. Prematurely reducing power to idle on round out resulting in hard landing.
G. Touchdown with excessive airspeed.
H. Excessive and/or unnecessary braking after touchdown.
I. Failure to maintain directional control.
J. Failure to recognize and abort a poor approach that cannot be completed safely.

5. RM: Hazards & Emergencies

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Landing & Go-Around AI.VII.F.R3a
B. VII. RM Concepts – Land and Hold Short Operations (LAHSO) AI.VII.F.R3b
C. VII. RM Concepts – Wind Shear AI.VII.F.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.F.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.F.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.F.R5
G. VII. RM Concepts – Collision Hazards AI.VII.F.R4

Conclusion:

Brief review of the main points

A short-field approach and landing requires the airplane to be flown at one of its critical performance capabilities while close to the ground to land safely in a confined area. You must have precise positive control of the airplane's rate of descent and as to produce an approach that will clear any obstacles, result in little or no floating during the roundout, and permit your airplane to be stopped in the shortest possible distance.

Private Pilot ACS Skills Standards

1. Maintain published airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots, with wind gust factor applied
2. Touch down at a proper pitch attitude within 200' beyond or on the specified point with no side drift, minimum

float, and with the longitudinal axis aligned with and over runway centerline.

Commercial Pilot ACS Skills Standards

1. Maintain published airspeed, or in its absence not more than 1.3 V_{SO}, ±5 knots, with wind gust factor applied.
2. Touch down at a proper pitch attitude within 100’ beyond or on the specified point, with no side drift, minimal float, and with the longitudinal axis aligned with and over the runway centerline.

VII.M. Slip to a Landing

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Aviation Weather Handbook (FAA-H-8083-28), POH/AFM

Objectives	The learner should develop knowledge of the elements related to forward slips, as well as sideslips and can perform either one. They can perform the forward slip to a landing as required in the ACS.
Key Elements	1. Maintain Ground Track 2. Steeper the bank angle, Steeper the descent 3. Smooth recovery
Elements	1. What is a Slip? 2. Practical Slip Limit 3. Forward Slip Operations 4. Performing the Forward Slip 5. Performing the Sideslip 6. Performance & Runway Selection 7. Common Errors 8. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Model Airplane
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can perform a slip to a landing, maintaining ground track, and adjusting as necessary to establish and maintain a stabilized approach.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Today we get to learn how to make the plane drop out of the sky - in a controlled way.

Overview

Review Objectives and Elements/Key ideas

What

A slip occurs when the bank angle of an airplane is too steep for the rate of turn. The airplane is in essence flying sideways which increases drag as well as the rate of descent, without increasing the airspeed.

Why

Intentional slips are used to dissipate altitude without increasing airspeed, and/or adjust airplane ground track during a crosswind. Intentional slips are especially useful in forced landings and in situations where obstacles must be cleared during approaches to confined areas. A slip can also be used as an emergency means of rapidly reducing airspeed in situations where wing flaps are inoperative or not installed.

How:

1. **What is a Slip?** AI.VII.M.K1
   A. A slip is a combination of forward movement and sideward movement
      i. The airplane is in fact flying sideways resulting in a change in the direction the relative wind strikes the plane
   B. Slips are characterized by
      i. An increase in drag
         a. Allows for the airplane to descend rapidly without an increase in airspeed
      ii. A corresponding decrease in airplane climb, cruise, and glide performance
   C. Positive Static Stability
      i. Most planes exhibit positive static directional stability and tend to compensate for slipping
         a. An intentional slip requires deliberate cross-controlling ailerons and rudder
   D. Two Types of Slips
      i. Forward Slip
         a. Used to steepen the descent angle without excessively increasing airspeed
            - Especially useful in forced landings and situations where obstacles must be cleared during approach
         b. Procedure
            - The wing on the side toward which the slip is to be made is lowered using the ailerons
            - Simultaneously, the nose is yawed in the opposite direction with opposite rudder
               a The longitudinal axis is at an angle to the original flight path
         c. The amount of slip, and therefore sink rate, is determined by bank (steeper bank = steeper descent)
      ii. Sideslip
         a. Used when landing in a crosswind to keep the aircraft aligned with the centerline and prevent drift
            - The longitudinal axis of the airplane remains parallel to the original flight path
         b. Procedure
            - Lower the wing into the wind
            - Apply just enough opposite rudder to keep the longitudinal axis aligned with the centerline
            - Aileron keeps the plane over the centerline; rudder keeps the longitudinal axis aligned with it

- The aircraft will touchdown on the upwind wheel, then the downwind wheel, then the nose wheel

2. Practical Slip Limit

A. In most light airplanes, the steepness of the slip is limited by the amount of rudder travel available

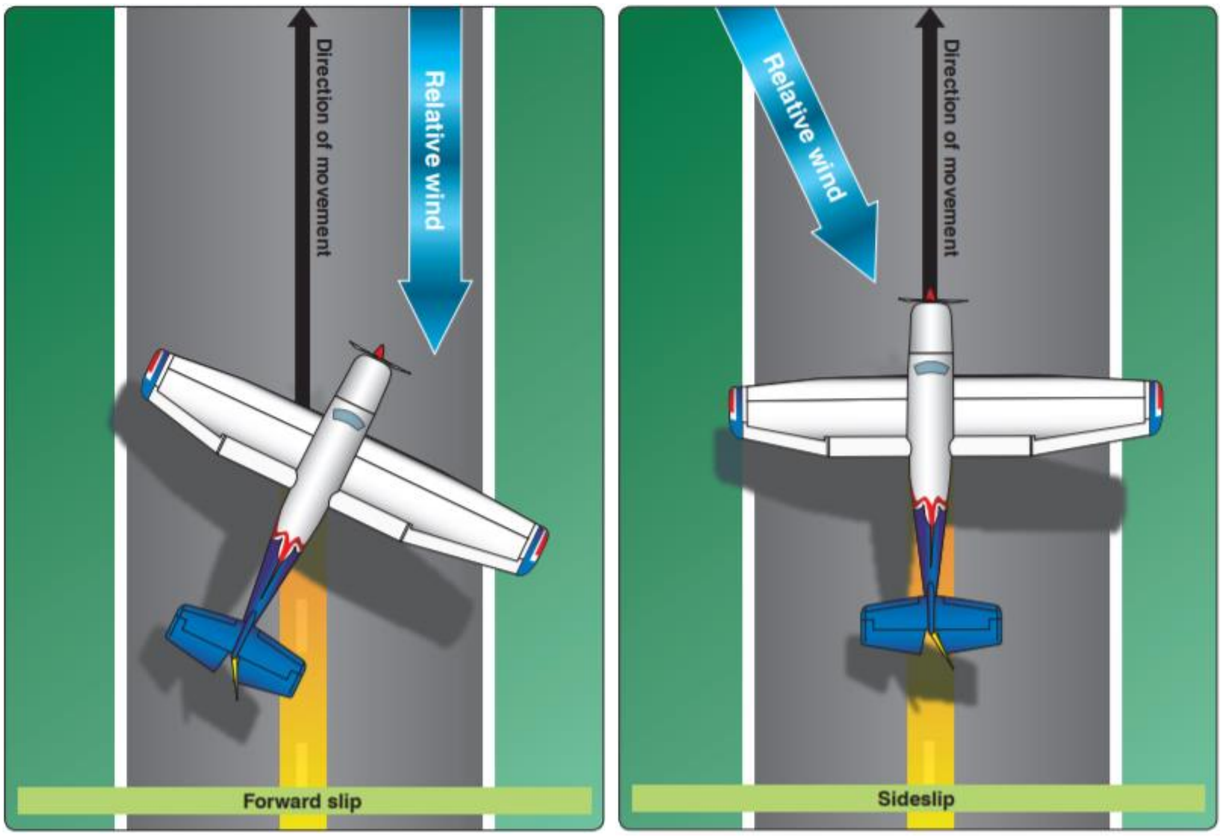
B. In both sideslips and forward slips, the point may be reached where full rudder is required to maintain heading even though the ailerons are capable of further steepening the bank angle

  i. This is the Practical Slip Limit: Additional bank causes the plane to turn even with full opposite rudder

C. If there is a need to descend more rapidly, lowering the nose will increase the sink rate as well as the airspeed

  i. Increased airspeed also increases rudder effectiveness permitting a steeper slip

  ii. Conversely, when the nose is raised, rudder effectiveness decreases, and the bank must be reduced



3. RM: **Forward Slip Operations** AI.VII.M.R7

A. Airspeed Indicator Errors

  i. Due to the location of the pitot tube/static ports, there may be airspeed indicator errors when in a slip

  ii. Airspeed is displayed based on the difference between static and ram air pressure

    a. A change in either the static or ram pressure will result in a change in the airspeed

    b. Static Error Example

      - With the static port on the left and left slip, the relative wind is from the left
        - a The static port now receives some amount of ram air pressure
        - b Static pressure has increased, and for arguments sake, ram pressure remains the same
        - c This results in a lower indicated airspeed than what is being flown
      - In a right slip, the airspeed indicator would show a higher speed than you are flying
      - Two static ports, one on each side of the fuselage, may compensate for and remove these errors

    c. Pitot Error Example

      - In a slip, the pitot tube is no longer pointed directly into the relative wind and therefore the ram air pressure may not be as accurate as in straight and level flight

iii. Reference the POH, and be aware of any known errors and/or limitations with your aircraft
  a. If airspeed jumps when the slip is removed, this is a good indication of airspeed error in a slip
iv. The pilot must be aware of the potential for errors and recognize a properly performed slip by the:
  a. Attitude of the airplane
  b. Sound of the airflow
  c. Feel of the flight controls

B. Stalls in a Slip
  i. If an airplane stalls in a slip, it displays little yawing tendency that tends to lead to a spin
    a. Tend to roll into a wings level attitude. Stall characteristics may even be improved
      - The raised wing has a higher AOA than the lower wing and will therefore stall first
        a This often reduces the bank angle and prevents a further stall
  ii. A cross-controlled stall can still be entered in a slip
    a. Can be extremely hazardous close to the ground - the aircraft may tend to roll over
    b. Maintain approach airspeed, and execute a go around if the approach is not stable
  iii. Tail Stalls with Flaps
    a. Not recommended to slip some aircraft with flaps extended, this is because it can result in a tail stall
      - Conditions/reasons vary, but in general, having the flaps extended at high AOAs blanks out the relative wind over the horizontal stab and leads to a tail stall (may not be possible to recover)
    b. Follow the manufacturer's recommendations, and remove the slip at any indication of stall

C. Fuel Flow
  i. In coordinated flight, fuel will flow normally from the tanks into the fuel delivery system, and in other than straight-and-level attitudes, centripetal force will replace gravity to force fuel "down" relative to the airplane.
  ii. In uncoordinated flight (forward slip) forces may pull fuel away from the fuel lines
    a. Potential to cause fuel starvation and engine stoppage
    b. Risk is greatest when fuel levels are low
  i. Remove the slip at any indication of engine coughing or roughness

4. Performing the Forward Slip AI.VII.M.K1, AI.VII.M.K2, AI.VII.M.K4

A. Setup & Configuration
  i. Checklists should be used as normal
  ii. The airplane will have to be established higher on final
    a. This is because the slip will result in a steeper than normal descent
    b. In a real-life scenario, with obstructions and/or hazards that must be cleared with a steep descent rate, be aware of the obstacles and the descent requirements – Plan ahead!
  iii. Reduce power to idle
    a. There is no logic in slipping to lose altitude with power
    b. Always keep one hand on throttle (within reason) – it may be necessary to immediately go around
  iv. Extend the flaps as necessary
  v. Slipping is not the first option when it is necessary to lose altitude
    a. Reduce power, lower the flaps and gear, use spoilers (if available), and if still necessary, then slip

B. Entry
  i. The wing on the side toward which the slip is to be made should be lowered by use of the ailerons
    a. Slip into the wind, if a crosswind exists
      - Wing down into the wind
  ii. Simultaneously, the airplane's nose must be yawed in the opposite direction by applying opposite rudder so that the airplane's longitudinal axis is at an angle to its original flight path
    a. The degree to which the nose is yawed should be such that the ground track is maintained
  iii. The nose of the airplane should be raised to prevent the airspeed from increasing

a. Use the necessary elevator pressure to maintain the proper pitch attitude and airspeed
  - Excessive nose high pitch attitudes can lead to a stall

iv. Adjust pitch to maintain airspeed

C. RM: Stabilized Approach (RM: Unstable approach) AI.VII.M.R9

i. Rate of Descent

a. The amount of slip, and therefore the sink rate, is determined by the bank angle
  - The steeper the bank, the steeper the descent
  - The steepness of a slip is often limited by the amount of rudder travel available (practical slip limit)
    - a For maximum descent rates, use full rudder and adjust aileron to maintain bank/ground track

b. Pitch Attitude
  - Maintain the desired approach speed during the slip with smooth, proactive pitch adjustments

ii. Precise Ground Track

a. The degree to which the nose is yawed in the opposite direction from bank should be enough that the airplane maintains a precise ground track
  - If the rudder is held constant, bank can be adjusted to maintain the desired ground track

iii. Crosscheck

a. The pilot's crosscheck should increase during a slip

b. Be aware of the slip configuration, ground track, airspeed, altitude, descent rate, current glidepath vs the desired glidepath, other traffic, ATC instructions, etc.

iv. Remove the slip and go around if unstable

D. Discontinuing a Forward Slip

i. Level the wings and release the rudder while adjusting the pitch attitude to the normal glide attitude

a. Recovery should be smooth
  - If the rudder pressure is released abruptly, the nose will swing too quickly into line and the airplane will tend to acquire excess speed
    - a Momentum can also carry the nose past straight ahead

ii. RM: Touching down in a side slip could be hazardous to pilot and aircraft (RM: Longitudinal axis misaligned) AI.VII.M.R8

a. Never land in a forward slip

b. Can impose severe side loads on the gear

c. Remove the forward slip and implement a sideslip for landing

5. Performing the Sideslip AI.VII.M.K1, AI.VII.M.K2, AI.VII.M.K4

A. Entering

i. Checklists should be used as normal

ii. Configuration

a. The airplane will have to be established higher on final, or anticipate a higher power setting to compensate for the increased drag
  - This is because the slip will result in a steeper than normal descent

b. Maintain power setting
  - In this case the objective of the slip is to align the airplane for a crosswind landing, and not to lose altitude. Therefore, the power is maintained

c. Extend the flaps as necessary

d. Always keep hand on throttle (within reason) - it may be necessary to immediately go around

iii. Entry

a. Enter by lowering the upwind wing into the wind and simultaneously applying just enough opposite rudder to prevent a turn
  - Apply aileron to keep the aircraft centered on the runway centerline

- Apply enough rudder to keep the nose of the aircraft aligned with the runway

b. The amount of slip, and therefore the rate of sideward movement (to compensate for the crosswind), is determined by bank angle
   - The steeper the bank angle, the greater the slip
     - a As bank angle is increased, additional opposite rudder is required to maintain alignment with the runway centerline

c. RM: Crosswind Limits AI.VII.M.R2a
   - At some wind speeds and angles, there may not be sufficient rudder authority to align the longitudinal axis with the runway
   - This is why there are crosswind limits in the aircraft POH
     - a Do not exceed the crosswind limits, they're published for a reason

d. The nose of the airplane should be raised slightly to prevent the airspeed from increasing
   - Use the necessary elevator pressure to maintain the proper pitch attitude

iv. Forward Slip to a Sideslip

a. There are cases in which a high rate of descent is required to establish the airplane on the desired glidepath, and the landing will be performed with a crosswind
   - In this case, the pilot will have to transition from a forward slip (to lose altitude) to a sideslip (to safely land in the crosswind)

b. As normal, the forward slip should be performed into the wind to make the transition cleaner
   - Once established on the normal glidepath, rudder and aileron required for the forward slip should be reduced and the sideslip established
     - a Reduce rudder to align the longitudinal axis of the airplane with the centerline of the runway
     - b Adjust aileron to keep the aircraft centered over the extended runway centerline

c. The sooner the airplane is on glidepath, the better
   - This provides more time for the pilot to establish a stable approach and sideslip

B. Stabilized Slip/Approach

i. Rate of Descent

a. Controlled by power adjustments
   - Same as a crosswind approach and landing - Pitch for airspeed, and power for altitude

b. Establish pitch attitude
   - Maintain a normal approach speed
   - Adjust power as necessary

ii. Precise Ground Track

a. Ailerons are used to keep the airplane over the runway centerline, while rudder is used to align the longitudinal axis with the flight path

b. As conditions vary (gusts, wind changes, updrafts/downdrafts, etc.) the pilot will have to adjust the aileron and rudder pressure to maintain the centerline
   - Use consistent, smooth, small control inputs

iii. If unstable, remove the slip and go-around

a. Excessive swings in descent rates, airspeed changes, and erratic ground tracks can be hazardous

C. Discontinuing (Landing in) a Sideslip

i. When landing in a sideslip, do not level the wings

a. Keep the upwind wing down throughout the roundout and touchdown
   - Touchdown on the upwind main wheel first

b. Removing the sideslip over the runway will result in drifting due to the crosswind AI.VII.M.R2a
   - This can result in a severe side load, or the aircraft being pushed off the runway entirely
   - Maintain crosswind corrections (sideslip) throughout the touchdown

ii. Directional control after touchdown
    a. Keep aileron into the wind. As speed slows, increase aileron until reaching full deflection at taxi speed
iii. Braking
    a. Brake evenly
    b. In a sideslip, with more pressure on one rudder, it's common to apply more pressure to that brake

6. **Performance & Runway Selection** AI.VII.M.K3
   A. Wind
      i. Headwind
         a. Decreases groundspeed and therefore landing distance
         b. Reduced groundspeed requires a slower rate of descent on final
      ii. RM: Tailwind AI.VII.B.R2c
         a. Increases groundspeed and therefore landing distance
         b. Increased groundspeed requires a higher rate of descent on final
      iii. RM: Ensure any crosswind is within limits (personal & POH) (RM: Effects of crosswind) AI.VII.M.R2a
   B. Aircraft Performance
      i. Atmospheric Pressure
         a. Since air is a gas, it can be compressed or expanded, affecting density
         b. Changes in air density affect performance - As density increases, performance increases & vice versa
      ii. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
         a. Density varies directly with pressure - As pressure increases, density increases and vice versa
         b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
         c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
         d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
      iii. How it affects Performance
         a. As the air becomes less dense, it reduces:
            - Power, since the engine takes in less air
            - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
            - Lift, because the thin air exerts less force on the airfoils
         b. Density Altitude & Landing
            - Affects power requirements on approach & climb capability in the case of a go-around
            - Higher density altitude = higher true airspeed which increases the landing roll
   C. RM: Runway Characteristics AI.VII.B.R2e
      i. Surface: More friction associated with softer surfaces – decreases landing roll
      ii. Gradient: Down sloping runway increases landing roll – reference the Chart Supplement for runway gradient
      iii. Condition: Dry, wet, snow, ice, etc. affects braking effectiveness
      iv. Available Distance: Runway length available for landing
   D. Performance Charts
      i. Take into account all of the above information, and more (weight, configuration, etc.)
      ii. Reference landing & climb performance charts (generally, landing distance/performance & climb performance or balked landing climb charts)
         a. Verify required distance and climb abilities are compatible with the runway/environment
   E. Pilot Capability
      i. Set and strictly adhere to personal minimums (runway length/width, winds, weather, etc.)
      ii. Ensure proficiency and safety
   F. Limitations are found in Chap 2 of the POH
   G. Applicable limitations can include maximum weights, crosswind/tailwind limitations, minimum runway length/width, flap/gear extension speeds, stall speeds, center of gravity limitations, etc.

7. **Common Errors** AI.VII.M.K5

A. Incorrect pitch adjustments that result in poor airspeed control.
B. Reacting to erroneous airspeed indications.
C. Using excess power while trying to lose altitude.
D. A slip in the same direction as any crosswind.
E. Poor glidepath control.
F. Late transition to a sideslip during landing with crosswinds.
G. Landing without the longitudinal axis parallel to runway.
H. Landing off the centerline.

8. RM: Hazards & Emergencies

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Landing & Go-Around AI.VII.M.R3a
B. VII. RM Concepts – Land and Hold Short Operations (LAHSO) AI.VII.M.R3b
C. VII. RM Concepts – Wind Shear AI.VII.M.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.M.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.M.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.M.R5
G. VII. RM Concepts – Collision Hazards AI.VII.M.R4

Conclusion:

Brief review of the main points

The slip to a landing increases the rate of descent, helping in many different scenarios. It is important to ensure the plane maintains the desired ground track. To adjust the rate of descent, increase or decrease the bank and make the necessary rudder inputs to maintain ground track. There's a point where we can no longer maintain ground track; this is the Practical Slip Limit. Ensure a smooth transition to landing to avoid sideloading and abrupt, violent maneuvering near the ground. To some extent, a sideslip can be used on almost every landing since the wind is rarely perfectly aligned with the runway. Use aileron to keep the aircraft over the runway, and rudder to align the longitudinal axis with the centerline.

Private Pilot ACS Skills Standards (Forward Slip to a Landing)

1. As necessary, correlate crosswind with direction of forward slip and transition to sideslip before landing.
2. Touch down at a proper pitch attitude, within 400 feet beyond or on the specified point, with no side drift, and the aircraft's longitudinal axis aligned with and over the runway center/landing path.

VII.N. Go-Around/Rejected Landing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of the Go-Around/Rejected Landing. The learner understands the importance of a prompt decision and can quickly and safely configure the airplane and adjust its attitude to accomplish a go-around. The learner will perform the maneuver to the standards prescribed in the ACS.
Key Elements	1. Power 2. Attitude 3. Configuration
Elements	1. Go-Around Situations 2. Making a Prompt Decision 3. Cardinal Principles 4. Climb Out 5. Communication 6. Performance Factors 7. Common Errors 8. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner shows the ability to recognize when a go-around is needed and promptly configures the airplane and adjusts its attitude to safely execute the rejected landing.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

There will be times when we must discontinue a landing and set up another one. This may be a result of a dangerous situation or may just be necessary to re-establish an approach. Either way, we want to know what we're doing as we're getting closer and closer to the ground.

Overview

Review Objectives and Elements/Key ideas

What

A go-around is the discontinuance of a landing approach to make another attempt to land under more favorable conditions (it is an alternative to any approach or landing). The go-around is a normal maneuver that may at times be used in an emergency. It is warranted whenever landing conditions are not satisfactory and the landing should be abandoned or attempted again.

Why AI.VII.N.K1

The need to discontinue a landing may arise at any point in the landing process and the ability to safely discontinue the landing is essential, especially due to the proximity of the ground.

How:

1. **Go-Around Situations**
   A. Air traffic control requirements
      i. Low approach only request
      ii. Told to go-around due to traffic, obstruction, etc. on the runway
   B. Unstable Approach
      i. Too low, too high, not aligned with the runway, airspeed control, rate of descent
      ii. A stable approach can be the most useful tool in avoiding a pilot induced go-around AI.VII.N.K2
         a. Set pitch and power, and make proactive adjustments to manage energy
            - Pitch for airspeed, power for altitude
         b. Maintain a stable site picture to the aim point
            - Proactively adjust for changing winds, up/downdrafts, etc.
      iii. Wind correction on approach & landing AI.VII.N.K4
         a. Crab to maintain track
         b. Transition to a sideslip when necessary on final approach
            - Adjust aileron to remain over the runway centerline (discuss site picture for centerline alignment)
            - Adjust rudder to align the longitudinal axis with the centerline
   C. Unexpected hazards on the runway (another airplane, vehicles, animals, etc.)
   D. Overtaking another airplane
   E. Wind Shear
   F. Wake Turbulence
   G. Mechanical Failure (Ex: Gear issues)
   H. Whenever safety dictates
2. RM: **Making a Prompt Decision**
   A. A go-around is not inherently dangerous, but becomes dangerous when delayed or executed improperly

B. RM: Delaying the Go-around (RM: Delayed performance of a go-around at low altitude) AI.VII.N.R2
   i. Stems from two sources:
      a. Landing Expectancy: Belief that conditions are not threatening, and the approach will end safely
      b. Pride: Mistaken belief that the act of going around is an admission of failure
C. RM: Delayed Recognition of the Need to Go-Around AI.VII.N.R1
   i. Set and maintain standard operating procedures (SOPs)
      a. Associate these SOPs with altitude gates
      b. Outside of SOP at the altitude gate = go-around
   ii. Ex: If you are not meeting specific SOPs at 500', go around
      a. Technique: Configured for landing, on airspeed (±5 knots), normal descent rate, on glidepath, aligned with the landing runway, before landing checklist complete
      b. Momentary deviations are acceptable
      c. Do not be trying to "fix" the approach within 500' of touchdown
   iii. Specific, measurable criteria allows for a logical easy decision (no emotion or questions)
   iv. If you're ever in doubt, go around
D. Important to *make a prompt decision*
   i. Do not provide any extra time to get closer to the ground, or for the hazardous situation to magnify
   ii. If there's a question as to whether to go-around, it's probably safer/smarter to go around
      a. Don't hesitate and stick to your decision. Safety first, always!

3. Cardinal Principles – Power, Attitude, Configuration AI.VII.N.K1

A. Improper execution stems from a lack of familiarity with the three cardinal principles of the go-around
B. RM: Power AI.VII.N.R3
   i. Power is the pilot's FIRST concern
      a. The instant the pilot decides to go-around, full power must be applied smoothly and without hesitation
         - Use a smooth and positive power input
            a Abrupt movements of the throttle may cause the engine to faulter
            b Carb heat should be off for maximum power
      b. Maintain full power until flying speed and controllability are restored
      c. RM: Improper power application
   ii. Inertia
      a. The pilot must be aware of the degree of inertia that must be overcome
         - It takes tremendous power to slow, stop, and reverse the downward inertia of an airplane
            a Newton's 1st Law - A body in motion wants to stay in motion
   iii. Controlling Power
      a. When takeoff power is applied:
         - The nose will rise suddenly
            a Nose is likely trimmed up for the approach due to lower power & airspeed
            b Hold forward pressure to maintain a safe attitude
               1. "Rough trim" should be used to relieve control pressures and maintain proper attitude
         - The nose will veer left
            a Use right rudder pressure to counteract the left turning tendencies, just like during takeoff
C. Attitude
   i. Attitude is always critical when close to the ground
      a. Raising the nose too early could result in a low altitude stall
         - Avoid the natural tendency is to immediately pull the nose up
      b. Lowering the nose too far could result in an accelerated descent to the ground
   ii. Maintain an attitude to allow the plane to build airspeed before any effort is made to gain altitude/turn
      a. Pitch attitude must slow/stop the descent

b. The airplane will not climb until reaching a safe speed
   - In some situations, it is desirable to lower the nose briefly to gain airspeed

iii. "Rough trim" the airplane
   a. A considerable amount of control pressure can be removed
   b. Quick relieving of the control pressures; trim more precisely when stable

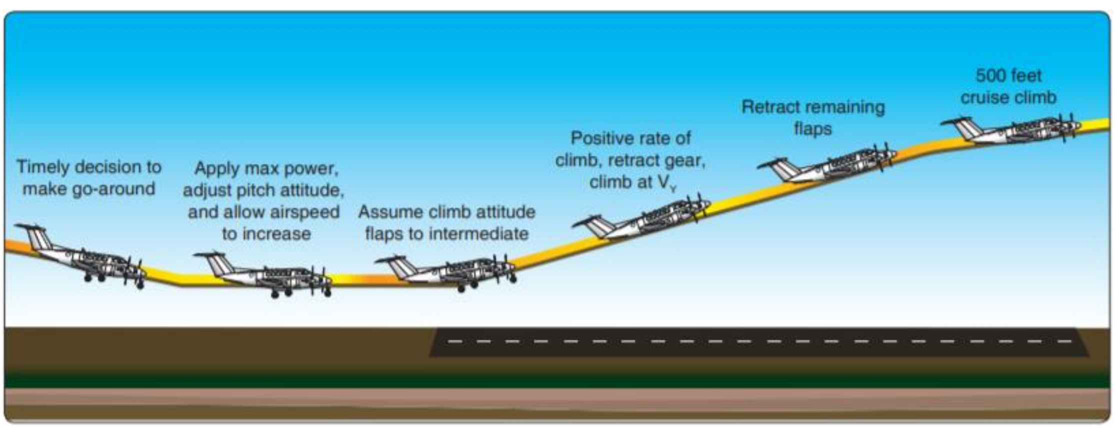
iv. Pitch for V_Y
   a. Begin the climb as soon as the appropriate climb airspeed and pitch attitude are attained
      - Pitch for and climb at V_Y (V_X, if necessary)

v. Summary: Increase power to max, stop the descent, and when safe, pitch to climb at V_Y (or V_X)

D. RM: Configuration AI.VII.N.R4
   i. Cleaning Up the Airplane
      a. 1st Concern: Landing Flaps
      b. 2nd Concern: Gear (if retractable)
      c. 3rd Concern: Takeoff Flaps
   ii. Flaps
      a. *In the DA20, after adding full power and establishing a climb attitude, retract the landing flaps
         - Incremental flap retraction allows time for the airplane to accelerate as they are being raised
         - A sudden/complete flap retraction could cause a loss of lift resulting in settling to the ground
   iii. Gear
      a. After a positive rate of climb is established, the gear can be retracted
         - Retract gear after the initial rough trim is established & when certain the plane will remain airborne
         - Do not retract the gear in a descent
            a In an extremely low go-around, it's possible for the plane to touchdown and bounce
            b Not particularly dangerous provided the plane is straight and a safe pitch attitude is maintained
   iv. Retract Takeoff Flaps
      a. At this point, treat the situation like a normal takeoff
      b. Retract the flaps as you normally would (after reaching V_Y and at a safe altitude)
   v. Flaps Before Gear
      a. In most aircraft full flaps produce more drag than the landing gear (reduces the most drag immediately)
      b. In the case the airplane inadvertently touches down, the gear is down & locked

E. Summary
   i. Increase power to max, stop the descent, and at a safe airspeed pitch to climb at V_Y (or V_X). Retract the landing flaps. Established in a positive rate of climb, retract the gear. Continue as in a normal takeoff

4. Climb Out



A. The majority of go-around climb outs will be identical to a normal takeoff climb out
   i. Adjust for wind and maintain the runway centerline

        ii. Especially important if there are parallel runways, or other hazards
    B. Maneuver to the side of the runway or landing area when necessary to clear and avoid conflicting traffic
        i. Ex: if another airplane is attempting to takeoff while you were close to landing
            a. You're blocked from their view by their roof, and they're blocked from your view by your plane's nose
            b. Move to a safe position parallel to the runway to keep the traffic in sight
                - If there are parallel runways, or other aircraft in the pattern, move to avoid other traffic
    C. Remain clear of obstacles/obstructions/other traffic
        i. Climb at V_X, if necessary to clear any obstructions
    D. Wind correction on takeoff/departure AI.VII.N.K4
        i. Crab into the wind to maintain the extended centerline
        ii. Select two or more visual reference points directly ahead of the plane (roads, towns, lakes, towers, etc.)
            a. Form an imaginary line between them and keep the airplane headed along that line
            b. If the points move out of alignment, make the necessary corrections to realign the airplane
        iii. Occasionally glance back toward the runway to ensure the proper track and no drift
        iv. If able, use a moving map to align your track with the extended runway centerline

5. Communication
    A. Once the airplane is under control, then you can communicate with the tower or appropriate facility
        i. Let them know you're "Going Around"
        ii. Aviate, Navigate, then Communicate – Fly first, then deal with the radios
    B. RM: Go-around with a LAHSO clearance (AIM 4-3-11 b(6)) AI.VII.N.R8
        i. LAHSO clearance does not preclude a go-around
        ii. If necessary, execute the go-around, maintain safe separation from other aircraft/vehicles and notify ATC

6. Performance Factors AI.VII.N.K3
    A. Atmospheric Conditions
        i. Atmospheric Pressure
            a. Since air is a gas, it can be compressed or expanded, affecting density
            b. Changes in air density affect performance - As density increases, performance increases & vice versa
        ii. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
            a. Density varies directly with pressure - As pressure increases, density increases and vice versa
            b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
            c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
            d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
        iii. How it affects Performance
            a. As the air becomes less dense, it reduces:
                - Power, since the engine takes in less air
                - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
                - Lift, because the thin air exerts less force on the airfoils
    B. Wind
        i. Headwinds increase climb performance (more airflow over the wings)
        ii. Tailwind decrease climb performance (reduced airflow over the wings)

7. Common Errors AI.VII.N.K5
    A. Failure to recognize a situation where a go-around/rejected landing is necessary
    B. Hazards of delaying a decision to perform a go-around/rejected landing
    C. Improper power application
    D. Failure to control pitch attitude
    E. Failure to compensate for torque effect
    F. Improper trim procedure
    G. Failure to maintain recommended airspeeds

H. Improper wing flaps or landing gear retraction procedure
I. Failure to maintain proper track during climb-out
J. Failure to remain well clear of obstructions and other traffic

8. RM: **Hazards & Emergencies**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.N.R7
B. VII. RM Concepts – Low Altitude Maneuvering AI.VII.N.R6
C. VII. RM Concepts – Collision Hazards AI.VII.N.R5
D. VII. RM Concepts – Runway Incursion AI.VII.N.R9

Conclusion:

Brief review of the main points

The go-around is a very important maneuver that is essential in an emergency. Knowing the procedure to properly perform the maneuver will provide a considerably safer situation. The pilot's first concern is power, followed by establishing the correct attitude, and configuration.

Private Pilot ACS Skills Standards

1. Apply takeoff power immediately and transition to V_X or V_Y as appropriate +10/-5 knots.
2. Maintain V_Y +10/-5 knots to a safe maneuvering altitude.

Commercial Pilot ACS Skills Standards

1. Apply takeoff power immediately and transition to V_X or V_Y as appropriate ±5 knots.
2. Maintain V_Y ±5 knots to a safe maneuvering altitude.

VII.O. Power-Off 180º Accuracy Approach & Landing

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner develops knowledge of the elements related to the power-off 180º accuracy approach and landing as required in the ACS.
Key Elements	1. Best Glide Airspeed 2. Wind Correction 3. Stabilized Approach
Elements	1. General 2. Selecting a Touchdown Point 3. The Maneuver 4. Common Errors 5. Hazards & Emergencies
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can perform a power-off 180º accuracy approach and landing, landing within 200' beyond the selected point. The learner can make the necessary corrections to maintain a stabilized approach to landing.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The power-off 180 is a challenging and very fun maneuver. Personally, it's one of my favorites…

Overview

Review Objectives and Elements/Key ideas

What

An approach and landing made by gliding with the engine idling through a 180º pattern begun abeam a specified touchdown point on the runway to a touchdown at or within 200' beyond that point.

Why AI.VII.O.K1

It instills judgment and procedures necessary for accurately flying the plane, without power, to a safe landing.

How:

1. **General** AI.VII.O.K1
   - A. Executed by gliding with the power off from a given point on a downwind leg to a preselected landing spot
     - i. The basic procedure involves closing the throttle at a given altitude and gliding to key positions. The pilot is constantly checking and adjusting the airplane's glide path to facilitate landing on the selected point
       - a. Key positions are points at which the pilot can judge the glide and if it will result in a safe landing
     - ii. The key points in a power-off 180º approach and landing are:
       - a. The downwind key position
         - Abeam the intended point of landing
         - Where the pilot reduces the power to idle
       - b. The base key position
         - On the base leg, 45º off the intended landing point
         - Generally, where the pilot starts configuring the aircraft
           - a Varies based on different aircraft and their performance, pattern size, altitude, wind, etc.
   - B. Configuring the Airplane
     - i. Normal landing configuration, but flaps are used as necessary to control the glide path of the approach
     - ii. Trim for best glide airspeed
   - C. Flying the Power Off Descent
     - i. Pitch attitude is used to maintain the best glide airspeed
       - a. Lower the nose to increase airspeed
       - b. Raise the nose to decrease airspeed
     - ii. Speeds other than the best glide airspeed
       - a. It is very important to maintain the best glide speed
       - b. Increasing the airspeed results in a steeper descent angle
       - c. Decreasing the airspeed results in rapid settling due to a slow airspeed and insufficient lift
         - Never try to stretch a glide to reach the desired landing spot
   - D. Attempt to fly a normal pattern, but also keep in mind that:
     - i. Winds and other factors (up/downdrafts, thermals, etc.) can change the pattern AI.VII.O.K3, AI.VII.O.K4
     - ii. Not a mechanical maneuver - altitudes, pattern size, configuring, etc. will be adjusted on each approach
     - iii. Tools at the pilot's disposal to adjust the size of the pattern/rate of descent:

a. Drag – Flaps, forward slips, drag devices (if available)
    - The forward slip should be performed into the wind (bank into the wind)
    - RM: Forward Slip Operations AI.VII.O.R7
        a Fuel Flow: Uncoordinated flight may pull fuel from away from the fuel lines/engine
        b Tail Stalls:
            1. Having the flaps extended at high AOAs may blank out the relative wind over the horizontal stabilizer and lead to a tail stall (could be unrecoverable)
        c Airspeed
            1. Control: With the slip established, adjust pitch to maintain desired airspeed
            2. Errors: Airspeed is displayed based on the difference between static and ram air pressure
                a. A change in either the static or ram pressure will result in a change in the airspeed
                b. The slip can affect static and/or pitot pressure – reference the POH for potential errors
        d For more details, see VII.M. Slip to a Landing – Forward

b. Airspeed – Faster or slower than best glide increases the rate of descent
c. Size of the pattern – Turning base early/late, dogleg to final, S-turns

E. Coordination
    i. Like always, keep the airplane coordinated (exception is a slip)
    ii. Don't attempt to increase the rate of turn with rudder; this could lead to a crossed-control stall

F. A stable approach is predictable
    i. Trim to maintain best glide and avoid large swings in pitch/airspeed

2. Runway & Touchdown Point

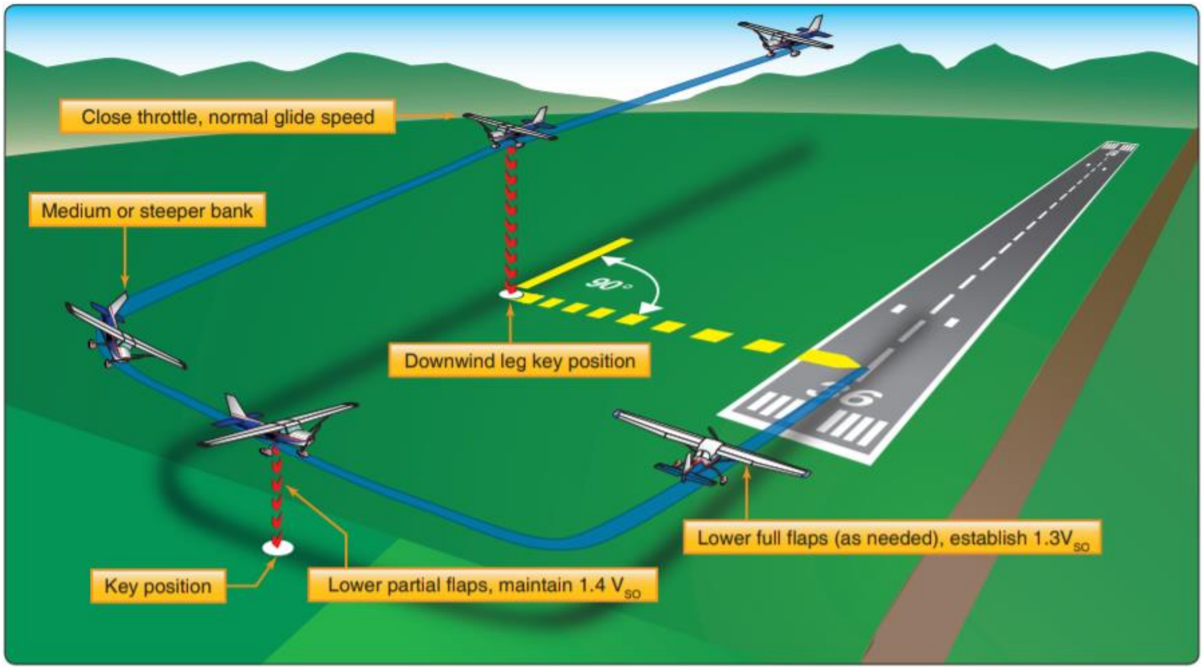
A. RM: Runway Selection AI.VII.O.R1
    i. Selection may be extremely limited in a real-life power-off landing
    ii. Wind
        a. Preferred to land with a headwind – reduces landing distance
        b. RM: Tailwinds increase ground speed and ground roll (RM: Effects of tailwind) AI.VII.O.R2c
        c. RM: Ensure any crosswind is within limits (personal & POH) (RM: Effects of crosswind) AI.VII.O.R2a
    iii. Runway Characteristics AI.VII.O.R2e
        a. Surface: More friction associated with softer surfaces decreases landing roll
        b. Gradient: Down sloping runway increases landing roll
        c. Condition : Dry, wet, snow, ice, etc. affect braking effectiveness
        d. Available Distance: Compare to the required landing distance
    iv. Performance Charts
        a. Take into account all of the above information, and more (weight, configuration, etc.)
        b. Verify required landing distance based on the specific conditions (atmospheric, airplane, etc.)
    v. Pilot Capability: Strictly adhere to personal minimums – Ensure proficiency and safety
    vi. Limitations: Reference any associated landing limitations in the POH

B. Touchdown & Aim Point
    i. Select an easily recognizable point (Ex: a specific centerline marking, the 500' or 1,000' markers, etc.)
    ii. Ensure there is ample space on both sides of the point
        a. It should allow for landing in the touchdown zone (first 3,000' or half, whichever is less)
        b. It should not be so close to the beginning of the runway that it risks a landing in the dirt
            - The float and touchdown should both be guaranteed to be over the runway surface
            - Aiming for "the numbers" is likely too short
    iii. Choose an Aiming Point. Aim Point Considerations:
        a. Standard flare/float distance (varies with aircraft – i.e. DA20 will glide a lot further than an Archer)
        b. Wind – headwind decreases float, aim closer to the touchdown point (opposite for tailwind)
        c. Airspeed – If approaching faster than normal, aim earlier (longer float)

3. The Maneuver AI.VII.O.K1

A. Downwind Leg - 1,000' AGL
   i. Complete the before landing checklist as normal (midpoint)
   ii. Abeam the selected touchdown point, reduce the throttle to idle
      a. This is the Downwind Leg Key Position
      b. *Upon doing this, maintain altitude until reaching best glide speed (73)
      c. Trim the aircraft for best glide speed, and start the descent
      d. Be aware of, and anticipate how the wind conditions will affect the pattern
         - Groundspeed, crab required, movement of ground references, ATIS, etc. can provide an idea of what wind conditions to expect
   iii. Turning to the Base Leg AI.VII.O.K3, AI.VII.O.K4
      a. The base leg is positioned as needed based on the altitude and/or wind condition
         - Position the leg to conserve or dissipate altitude as required to reach the landing point
            a The turn onto the base leg is made at an altitude high enough and close enough to permit the airplane to glide to what would normally be the base key position in a 90º power-off approach
         - If the headwind on final is strong and/or the plane is low, start base early to avoid landing short
            a In the case of a strong wind, groundspeed will be lower resulting in less ground covered
            b The stronger the headwind, the smaller the pattern
         - If wind is calm, and/or the plane is high, extend downwind to avoid overshooting the landing point
            a Crosswinds are similar to calm wind, but adjust bank to prevent over/undershooting the runway
      b. The turn to the base leg is a uniform turn with a medium or slightly steeper bank
         - The degree of bank and amount of turn depend on the glide angle and the wind velocity

B. Base Leg
   i. Continue the glide, evaluating the airplane's position in relation to the landing point
      a. Adjust the crab to maintain the base leg
         - The size of the crab is a good indication of the wind on final
      b. Adjust the base leg as required
         - Ex: If very low, the pilot may choose not to square the turn to final, but instead fly a dogleg to final
   ii. Base Key Position – 45º to the landing point
      a. Use this position to further evaluate the descent and adjust
      b. Approach flaps may be used at this position, conditions permitting
         - This will vary based on the aircraft, and the current situation
         - Full flaps are not used until established on final
   iii. Tailwind on the base leg AI.VII.O.K3, AI.VII.O.K4
      a. A tailwind on the base leg (crosswind on final), tends to result in being higher than in a calm wind, and a headwind on the base leg, tends to result being lower than normal
         - With a tailwind, airplane will not lose as much altitude on base due to the higher groundspeed
         - With a headwind, the airplane will lose more altitude because of the lower groundspeed
   iv. Aim Point
      a. As in a normal approach to landing, use an aim point
         - A steady position is desired – the airplane is maintaining the glidepath to the landing point
         - If the aim point is moving up, the airplane is moving below the glidepath
            a Maintain best glide and delay configuring
         - If the aim point is moving down, the airplane is moving above the glidepath
            a Consider increasing drag: Slip, s-turns, and/or configuring early



C. Turning to Final
  i. Plan the turn so that the airplane rolls out aligned with the runway centerline
    a. Adjust for over or undershooting winds

D. Final Approach
  i. Continue to evaluate the approach and make necessary adjustments to reach the aim point
    a. Turn early/head directly to the runway from the base leg if necessary to make the landing point
    b. Flaps may be used to increase the descent rate and slow the airplane to landing speed
      - Lower the approach flaps if they were not already lowered on the base leg
      - Lower the landing flaps on final approach when landing is assured
      - Remember, flaps result in a slower airspeed and an increased sink rate
        a It may be necessary to be slightly high when using the flaps, or it may be necessary to accept the balloon associated with adding flaps to stay on proper approach path
  ii. Double check the landing checklist has been completed
    a. High stress situations can lead to mistakes and/or entirely missed checklists
  iii. Maintain a Stabilized Approach AI.VII.O.K2
    a. Adjust as the aim point moves higher or lower in the windscreen
      - If the point is moving up in the windscreen, the aircraft is getting low
        a Don't necessarily add flaps immediately
          1. Gauge the situation – if it's going to be close, the pilot can go directly to the runway, and use flaps closer to the ground to balloon/float vs adding flaps and creating a steep descent
      - If the point is moving down in the windscreen, the aircraft is getting high
        a Use remaining flaps, S-turns, slip, reduce the airspeed, or decrease the pitch attitude and aim slightly before the original aim point (100' - 150')
    b. Slight adjustments help to maintain a stabilized approach and lead to an on-target landing
      - Do not wait for large aim point changes, be proactive
      - Large changes lead to inconsistent descent rates, large speed swings, and an unstable approach

E. Roundout and Touchdown
  i. Although accurate spot landings are important, safe & properly executed approaches and landings are vital
    a. Never sacrifice a good approach or landing just to land on the desired spot

ii. The Commercial ACS requires the pilot to touchdown at a proper pitch attitude, within 200' beyond or on the specified point with no side drift and with the longitudinal axis aligned with and over the centerline
   a. Make a safe, normal, power-off landing
   b. *Remember, the airplane will normally glide approximately 400' - 500' before touching down
      - If necessary, and safe, hold the airplane in ground effect until reaching the touchdown point
   c. Don't force the plane down & don't stretch the glide as it may result in a hard landing/stall
   d. Correct for crosswinds

iii. Hold back elevator pressure after touchdown
   a. Land on the main gear and keep pressure off the nosewheel to allow it to gently touchdown
   b. Do not force the plane on to the ground

F. Directional Control
   i. Maintain directional control with rudder, and apply the necessary crosswind correction
   ii. After touchdown, brake smoothly and evenly

4. Common Errors AI.VII.O.K5

A. Failure to establish approach and landing configuration at proper time or in proper sequence
B. Failure to identify the key points in the pattern
C. Failure to establish and maintain a stabilized approach
D. Failure to consider the effect of wind and landing surface
E. Improper use of power, wing flaps, or trim
F. Improper procedure during roundout and touchdown
G. Failure to hold back elevator pressure after touchdown
H. Poor directional control after touchdown
I. Improper use of brakes

5. RM: **Hazards & Emergencies**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VII. RM Concepts – Rejected Landing & Go-Around AI.VII.O.R3a
B. VII. RM Concepts – Land and Hold Short Operations (LAHSO) AI.VII.O.R3b
C. VII. RM Concepts – Wind Shear AI.VII.O.R2b
D. VII. RM Concepts – Wake Turbulence AI.VII.O.R2d
E. VII. RM Concepts – Distractions, Task Prioritization, SA AI.VII.O.R6
F. VII. RM Concepts – Low Altitude Maneuvering AI.VII.O.R5
G. VII. RM Concepts – Collision Hazards AI.VII.O.R4

Conclusion:

Brief review of the main points

The power-off 180º accuracy approach and landing consists of constantly evaluating and adjusting the approach as necessary based on the wind, altitude, groundspeed, and other factors.

Commercial Pilot ACS Skills Standards

1. Touch down at the proper pitch attitude, within 200' beyond or on the specified touchdown point with no side drift, minimum float, and with the airplane's longitudinal axis aligned with and over the runway centerline.

VII. RM Concepts

- For Takeoff lessons (Normal, Soft-field, Short-field) use the left Takeoff column & all following concepts
- For Landing lessons (Normal, Soft, Short, Slip, Power-Off 180), use the right Landing column & all following concepts
- For Traffic Patterns, only use Wind Shear, Wake Turbulence, and Distractions
- For Go-Arounds, only use Distractions, Low Altitude Maneuvering, Collision Avoidance, and Runway Incursion
- This is done to avoid repeating identical RM concepts 10x

TAKEOFF LESSONS

Rejected Takeoff

A. Circumstances such as engine malfunctions, inadequate acceleration, runways incursion, ATC conflict, or another emergency can result in a takeoff having to be rejected on the runway
   i. Ensure sufficient runway to accelerate to V_R and stop on the runway

B. Prior to takeoff, identify a point at which the plane should be airborne
   i. If not airborne, take immediate action

C. Rejected Takeoff Procedures
   i. Follow procedures specified in the POH
   ii. Generally, power idle, and apply maximum braking while maintaining directional control

D. If required to shut down the engine due to a fire, or any other reason
   i. Mixture to idle cutoff and magnetos off

E. Soft-Field Takeoff
   i. Maintain back pressure during the reject
      a. Avoid the nose digging in and cartwheeling or flipping
   ii. Max braking may be dangerous and unnecessary

F. Short-Field Takeoff
   i. Especially important to take immediate action in the case of a rejected takeoff
   ii. Delaying may result in running out of runway or inability to clear an obstacle

LANDING LESSONS

Rejected Landing & Go-Around

A. When to Go-Around
   i. When it's hazardous to continue or if you're ever in doubt of the safety of the approach

B. Cardinal Principles: Power, Attitude, Configuration

C. Not inherently dangerous, but becomes dangerous when delayed or flown improperly
   i. Delaying often stems from two sources:
      - Landing expectancy: Belief that conditions are not as threatening as they are, and the approach will end safely
      - Pride: Mistaken belief that a go around is an admission of failure

D. Decision making
   i. Maintain a stabilized approach
      a. *Momentary* deviations from speed, glidepath and centerline are acceptable
      b. Set altitude gates
      - If you don't meet set criteria at specified altitudes, go-around (no questions asked)
      - Ex. Stable and configured for landing at 500'
   ii. In an emergency, you may have to choose between a go around or continuing to land
      a. Go Around Considerations
      - There are situations that can be handled better airborne than on the ground
         a Ex: landing gear. Go around and attempt to solve the problem airborne
      b. Continuing to Land Considerations
      - There are situations that can be better handled by landing instead of going around
         a Ex: emergencies that can affect the airplane's ability to fly, or fire

Engine Failure

A. Time is of the essence
   i. Unless prepared in advance, there is a strong chance the pilot makes a poor decision or no decision
      a. "We don't rise to the level of our expectations; we fall to the level of our training"
      b. Practice, Plan, then Brief the plan

B. Procedures
   i. Step one, Maintain aircraft control
   ii. During the takeoff roll
      a. Reject the takeoff and stop straight ahead
   iii. Immediately following takeoff
      a. If there is sufficient runway available straight ahead, land on the remaining runway
      b. Ensure you know how much runway you need (descent + landing distance)
   iv. During the takeoff climb
      a. Aircraft will have full power, a high pitch attitude and right rudder
      b. When the engine fails, lower the nose (best glide) and release right rudder
      c. Once in control, establish a glide toward a plausible landing area
         - Know at what altitude/distance you can return to the airport
         - Continue with engine failure procedures
      d. Time and altitude permitting, notify ATC, accomplish applicable checklists, attempt a restart

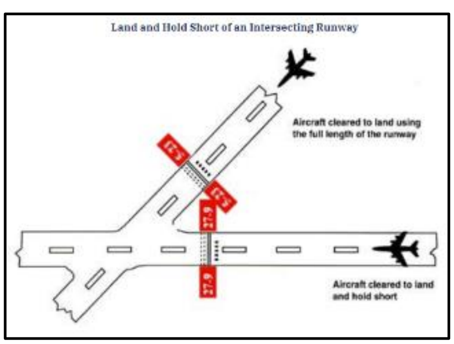
Land and Hold Short Operations (LAHSO)

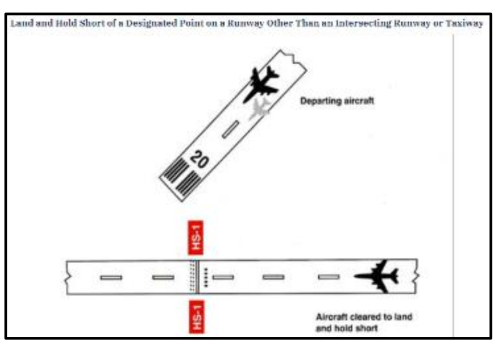
A. Basics
   i. Operations that include landing and holding short of an intersecting runway, taxiway, or other point

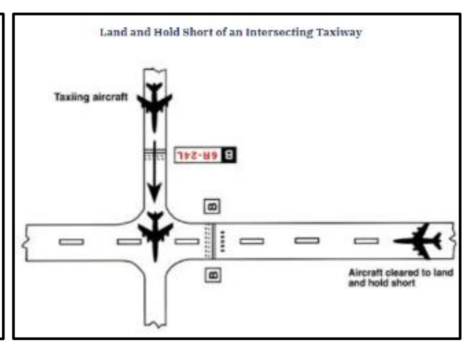
B. Pilot Responsibilities
   i. Preflight Planning
      a. Become familiar with all LAHSO information at the destination
      b. Landing performance – knowledge of landing data allows for a quick decision
   ii. PIC has the final authority to accept or decline any LAHSO clearance
      a. Once accepted, a LAHSO clearance must be adhered to, unless otherwise coordinated
         - Does not prevent a rejected landing
   iii. Full readback of LAHSO clearance is required

C. Situational Awareness
   i. Have current airport information (diagram, LAHSO procedures, etc.)
   ii. To conduct LAHSO operations properly, understand the following:
      a. Landing distance available
      b. Be advised by ATC as to why LAHSO are being conducted
      c. Advise if you cannot accept LAHSO
      d. LAHSO/airport signs, markings, lights
      e. Not authorized for solo student pilots
      f. Air carriers are often not authorized LAHSO if the other aircraft is GA
      g. Generally, not authorized at night
      h. Not authorized on wet runways
   iii. LAHSO Minimums
      a. Basic VFR: 1,000' ceiling & 3 SM visibility

D. LAHSO examples shown below







3. Wind Shear

A. Wind Shear

i. What is it?

a. A sudden, drastic change in wind speed and/or direction over a very small area

b. Can occur at any altitude; low-level wind shear is especially hazardous due to proximity to the ground

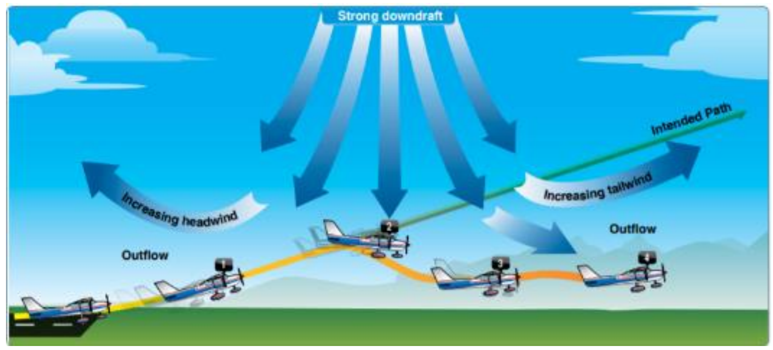
- Low-level wind shear is commonly associated with passing frontal systems, thunderstorms, temperature inversions, and strong upper-level winds (greater than 25 knots)

ii. Why is it dangerous?

a. Can subject an aircraft to violent updrafts & downdrafts, and abrupt changes to horizontal movement

b. It can rapidly change the performance of the aircraft and disrupt the normal flight attitude, for example:

- A tailwind can quickly change to a headwind causing an increase in airspeed and performance
- A headwind can quickly change to a tailwind causing a decrease in airspeed and performance



c. Microbursts

- Most severe type of wind shear
- Characteristics
- 1-2 miles across
- Lifespan of 5-15 mins.
- Strong downdrafts
- Strong turbulence
- Headwind gains/losses of 30-90 knots
  - a Strong turbulence and hazardous wind direction changes
- Takeoff through a Microburst
  - a Aircraft will first experience a performance-increasing headwind
  - b Followed by performance-decreasing downdrafts
  - c Followed by a rapidly increasing tailwind
    1. Can result in terrain impact or flight dangerously close to the ground
  - d An encounter on approach involves the same events and could force the plane to the ground
- Indications
  - a Visual: Intense rain shaft at the surface, but virga at cloud base, ring of blowing dust
  - b Alerting Systems
    1. The FAA has invested in substantial microburst accident prevention
    2. LLWAS-NE, TDWR, and ASR-9 WSP systems installed at major airports
       a. Very few false alerts, and detects well above 90% detection rate requirement
    3. Many airports, especially smaller airports, have no wind shear systems

d. If at all possible, avoid it

- Never conduct traffic pattern operations near an active thunderstorm
  - a Be alert for visual cues and any alerting systems and do not takeoff if wind shear is in the area
- LLWAS (Low Level Wind Shear Alerting System), if available, can warn of impending wind shear
- PIREPS can be very informational/helpful if a pilot has reported wind shear in the area

e. Approach into Wind Shear

- Follow POH procedures. If none, general wind shear techniques include:
  - a Higher power and a faster airspeed during approach
    1. Add ½ the gust factor to the approach speed
  - b Stay as high as feasible until necessary to descend (altitude is your friend)
  - c Go around at the first sign of an unexpected pitch or airspeed change

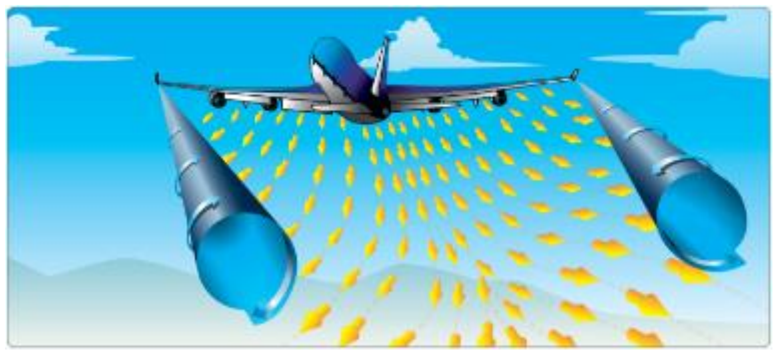
1. FULL power and get the airplane climbing
2. If still descending, ensure max power, and increase pitch as far as possible without stalling
    a. Intent is to keep the plane flying as long as possible in hope of exiting the shear

- Aviation Weather Handbook (FAA-H-8083-28)
    a See Ch. 22 pgs. 7-18 for details on recognizing/avoiding microbursts, and strategies for successful escape

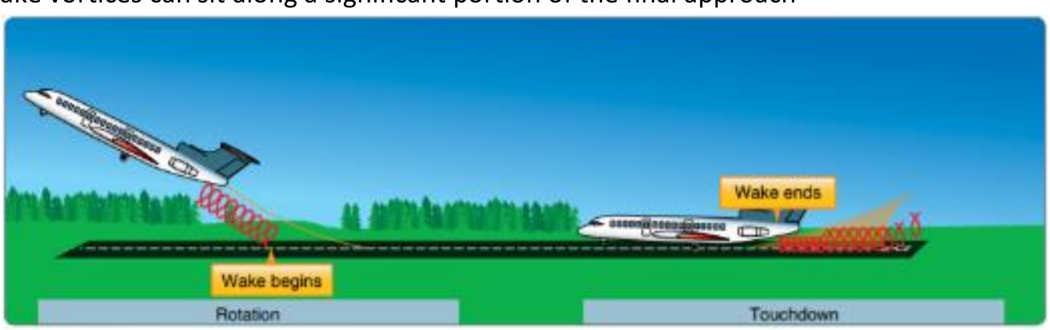
4. Wake Turbulence

A. What is it?
  i. Wake turbulence, or wingtip vortices, are the byproduct of lift
    a. Difference between the high pressure below the wing and low pressure above the wing causes the air to move outward, upward and around the wingtips, leading to counter rotating vortices
  ii. All aircraft generate wake turbulence during flight
    a. Generally, the larger the aircraft, the stronger the vortices
    b. Strength can vary
      - Strongest when the pressure differential is the greatest - when heavy, clean, and/or slow
      - Turbulence from a "dirty" configuration accelerates the decay of the wake turbulence

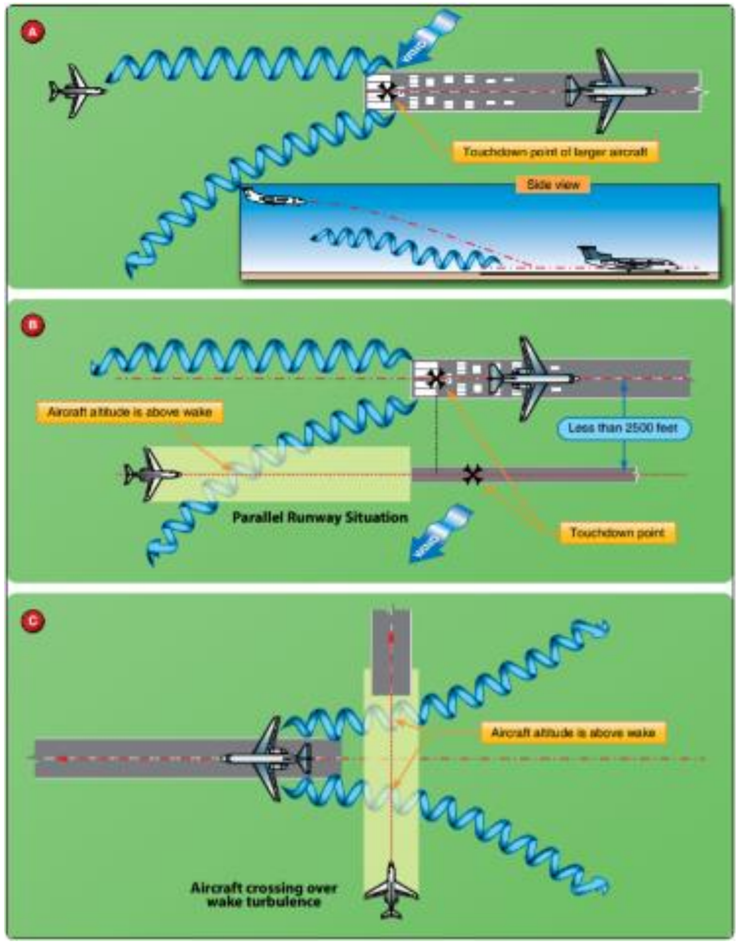
iii. Why is it dangerous?
  a. The rolling moments caused by the wake turbulence of a larger aircraft can exceed control authority
  b. Potential for to damage aircraft components and equipment
  c. Possible in any phase of flight
    - Although usually strongest during in all phases of flight



ii. Vortex Behavior
  a. Vortices are generated from the moment an aircraft leaves the ground, until it touches down
  b. Remain a bit less than a wingspan apart, drifting with the wind, at altitudes > a wingspan above the ground
  c. Sink at a rate of several hundred feet per minute, slowing descent and diminishing in strength over time
    - When large aircraft vortices sink to the ground (100-200'), they tend to move laterally at 2-3 knots
    - Crosswinds decrease lateral movement of the upwind vortex & increase movement of the downwind vortex
    - Light quartering tailwind produces the worst scenario
      a Wake vortices can sit along a significant portion of the final approach



D. Avoidance Procedures
  i. Landing behind a large aircraft:
    a. On the same runway
      - Stay at or above their approach path and land beyond their touchdown point (Figure A)
    b. On a parallel runway (< 2,500' away)



- Consider the possibility of drift, stay at or above their flight path, note touchdown point (Figure B)

c. On a crossing runway
- Cross above their flight path (Figure C)

d. Departing on the same runway
- Land prior to their rotation point

e. Departing a crossing runway: Note their rotation point, if that point is past the intersection, land prior to the intersection
- If they rotate prior to the intersection, avoid flight below its flight path
- Abandon the approach unless a landing is ensured well before reaching the intersection

f. Executing a low approach, missed approach, or touch-and-go
- Wait at least 2 minutes prior to a landing or takeoff
- Vortex hazard may exist along the runway/in the flight path, particularly in a quartering tailwind

ii. Departing after a large aircraft

a. On the same runway
- Rotate prior to their rotation point and climb above their climb path until turning clear

b. Executing a low approach, missed approach, or touch-and-go
- Wait at least 2 minutes prior to a landing or takeoff
- Vortex hazard may exist along the runway/in the flight path, particularly in a quartering tailwind

iii. Intersection takeoffs on the same runway

a. Be alert to adjacent large aircraft operations, particularly upwind of the runway of intended use

a. Avoid headings that cross below the larger aircraft's path

5. Distractions (Task Prioritization, Loss of SA, Disorientation)

A. Distractions

i. They're dangerous

a. Can lead to slow speeds, unintended aircraft attitudes, collisions, disorientation, missed radio calls, etc.

b. Remove distractions from your field of view or, if a person, explain the situation and ask them to stop

ii. Sterile flight deck

a. Maintain a sterile flight deck during taxi, takeoff, and climb as well as descent and landing

iii. Fly first! Aviate, Navigate, Communicate

a. Focus on the tasks at hand and stay ahead of the aircraft

B. Situational awareness (SA) & Disorientation

i. Extremely important, especially in the traffic pattern

a. Lost SA has led to unsafe situations, mishaps, and incursions

ii. Maintain SA

a. Know where you are, what's coming next, and stay ahead of the airplane
b. Be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
c. If SA or orientation is lost, admit it
    - If there's another pilot, let them take over while you catch up, if not, get the aircraft in a safe position (if landing, go around; if disoriented, trust the instruments and get to a safe attitude/altitude) and then solve the problem

iii. Disorientation: Get the aircraft to a safe attitude, airspeed, and altitude

C. Task Prioritization
  i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
    a. No one responsibility should take your full attention full more than a short period
  ii. Understand what tasks need to be accomplished and when
    a. Checklists and standard operating procedures are extremely helpful and enhance safety
    b. Prioritize tasks based on importance and time available
  iii. Recognize when you are getting behind and find a way to catch up
    a. If more time is needed, find somewhere to hold/circle, or slow down
    b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
    c. "Attack the closest alligator" – Deal with the most pressing problem
  iv. Safety is the number one priority
    a. Aviate, Navigate, Communicate

6. Low Altitude Maneuvering

A. A small problem at high altitude can quickly become a big problem at a low altitude
  i. There is considerably less time to handle any issues at a low altitude
B. Be aware of, and avoid obstructions on and around the airfield
  i. Quick, panicked maneuvers, especially when slow, can result in a stall or loss of control close to the ground
C. Low Altitude Stall/Spin
  i. A low altitude stall or spin can leave little to no recovery time
    a. ALWAYS maintain coordination, and airspeed at low altitudes
    b. If you get any indication of a stall at low level, recover and climb to a safe altitude
  ii. Spin
    a. A spin is a result of a stall + yaw
    b. Prevention
      - Recover at the first sign of a stall
      - Maintain coordination
      - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
    c. Recovery (PARE)
      - Power - Idle
      - Ailerons - Neutral
      - Rudder - Full rudder opposite the spin direction
      - Elevator - Brisk, positive forward pressure (nose down)
      - Once the spin has stopped, neutralize the rudders and raise the nose, being careful not to stall again
    d. Different aircraft respond differently to spins and spin recoveries, follow the POH procedures
D. CFIT (Controlled Flight into Terrain)
  i. AC 61-134: General Aviation CFIT Awareness
  ii. The solution to combating CFIT accidents starts on the ground
    a. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    b. How the flight is planned and handled largely determines the safety of the flight

iii. Recommendations:
   a. Non-instrument rated VFR pilots should not attempt to fly in IMC
   b. Know and fly above minimum published safe altitudes
   c. If IFR, fly published procedures
   d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter
   e. Verify all ATC clearances. Question potentially hazardous clearances
   f. Maintain situational awareness both vertically and horizontally
   g. Comply with appropriate regulations for your specific operation
   h. Don't operate below minimum safe altitudes if uncertain of position or ATC clearance
   i. Be extra careful when operating in an area which you are not familiar
   j. Use current charts and all available information
   k. Use appropriate checklists
   l. Know your aircraft and its equipment

7. Collision Hazards

A. Collision Avoidance
- i. Scanning
  - a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
    - Each movement should not exceed 10º, each area should be observed for at least one second
- ii. Clearing Procedures
  - a. Before Takeoff: Scan the runway and final approach for other traffic
  - b. Climbing: Execute gentle banks to allow scanning above/below the wings as well as other blind spots
  - c. Pattern: Scan for other traffic (especially important entering the pattern)
  - d. Approach: Clear the runway
  - e. Uncontrolled Fields: Be conservative with spacing during takeoff, landing, and in the pattern
    - Clearly communicate intentions & location at uncontrolled fields
- iii. Operation Lights On
  - a. Voluntary FAA safety program to enhance the see and avoid concept
  - b. Turn on landing lights during takeoff and when operating below 10,000', day or night
    - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected
- iv. Right-of-Way Rules (FAR 91.113)
  - a. An aircraft in distress has the right-of-way over all other traffic
  - b. Converging Aircraft
    - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
    - If the aircraft are different categories:
      - a Basically, the less maneuverable aircraft has the right-of-way
        - 1. Balloons, gliders, and airships have the right of way over airplanes
      - b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
  - c. Approaching Head-on: Each pilot shall alter course to the right
  - d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
  - e. Landing
    - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
      - a Do not take advantage of this rule to force an aircraft off the runway which has already landed
    - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
      - a Don't take advantage of this rule to cut in front of another aircraft

B. Terrain
- i. Be aware of terrain that could cause a hazard during the climb or descent into the airfield
  - a. Study charts and use maximum elevation figures (MEFs) and other data

   ii. Day vs Night flying over terrain
      a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
      b. A personal minimum may be to only fly over high terrain during daylight
   iii. Minimum Safe Altitudes (FAR 91.119)
      a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
      b. Over Congested Areas: 1,000’ above the highest obstacle within 2,000’
      c. Over other than Congested Areas: 500’ above the surface, except when over open water/sparsely populated areas, then no closer than 500’ to any person, vessel, vehicle, or structure
C. Obstacles and Wire Strike
   i. Many structures can significantly affect safety when below 500’ AGL and particularly below 200’ AGL
      a. Obstacles can be found in the NOTAMs, and the Terminal Procedures (IFR document)
      b. < 200’ AGL are unmarked/lighted power lines, antenna towers, etc.
   ii. Antenna Towers: Numerous antennas extend over 1,000’-2,000’ AGL
      a. Most are supported by guy wires which can extend 1,500’ horizontally
   iii. Overhead Wires: Wires and lines span runway departures and landmarks pilots frequently follow
      a. Lakes, highways, railroad tracks, etc.
      b. May not be lighted
D. Airport Surface
   i. Scan vigilantly during taxi for aircraft and obstacles
      a. Ensure proper clearance - If unsure of clearance, stop until you’re sure it is safe to pass
   ii. Vehicles, Persons, Wildlife, etc.
      a. Be alert for anyone/anything that may cause a hazard
         - Often the ATIS/NOTAMs will inform of potential vehicles/persons working around the airport
         - Wildlife is common around many airports.
      b. Takeoff: Reject the takeoff or delay takeoff, if required
      c. Landing: Go around
      d. Taxiing: Stop until safe to proceed

8. Runway Incursion (Only required by Normal Takeoff & Go-Around/Rejected Landing)
A. Be aware of the airplane’s position and be aware of other aircraft and vehicle operations on the airport
B. Readback all runway crossing and/or hold short instructions
C. Review airport layouts
D. Know airport signage
E. Review NOTAMs
F. Study & use proper phraseology
G. Write down taxi instructions
H. Request progressive taxi instructions when necessary
I. Check for traffic before crossing any runway hold line or entering any taxiway
J. Turn on lights and the rotating beacon or strobes when taxiing
K. When landing, clear the runway as soon as possible and wait for taxi instructions before moving
L. Go-Around/Rejected Landing
   i. Many of the above don’t apply
   ii. Maintain situational awareness – be aware of other aircraft and their position in the pattern or on the field
   iii. A runway incursion from another aircraft may require a go-around
      a. Confirm LAHSO ability and readback LAHSO instructions

FUNDAMENTALS OF FLIGHT

VIII.A. Straight-and-Level Flight

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives

The learner should develop the ability to maintain straight-and-level flight primarily using outside visual references. The learner should be able to reference the instruments inside the airplane to ensure straight-and-level flight is continued. The ability to effectively trim the airplane for straight-and-level flight should also be developed.

Key Elements

1. Control *Pressures*
2. Outside 90%, Inside 10%
3. Trim the airplane

Elements

1. Flight Controls
2. Control Pressures & Trim
3. Integrated Flight Instruction
4. Straight and Level Flight
5. Common Errors
6. Hazards

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment

1. White board and markers
2. References

IP's Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP's Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards

The learner understands how to keep the aircraft in straight-and-level flight. They can also relieve the control pressures by trimming the aircraft and provide light, positive, proactive control pressures when aircraft attitude needs to be corrected.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Straight and level flight. As simple as it may sound, it's the foundation for all maneuvers and where you'll spend the large majority of any flight (outside of training).

Overview

Review Objectives and Elements/Key ideas

What

Flight in which a constant heading and altitude are maintained. It is accomplished by making immediate and measured corrections for deviations in direction and altitude from unintentional slight turns, descents, and climbs

Why AI.VIII.A.K1

It is impossible to emphasize too strongly the necessity for forming correct habits in flying straight-and-level. All other flight maneuvers are in essence a deviation from this fundamental flight maneuver. It is not uncommon to find a pilot whose basic flying ability consistently falls just short of minimum expected standards, and upon analyzing the reasons for the shortcomings we discover that the cause is the inability to fly straight and level properly.

How:

1. **Flight Controls** AI.VIII.A.K2
   - A. Axis of Rotation
     - i. Pitch - Lateral Axis
     - ii. Roll - Longitudinal Axis
     - iii. Yaw - Vertical Axis
   - B. Pitch
     - i. Controlled by the elevators
       - a. Back pressure
         - Deflects the trailing edge of the elevator surface up
           - a Decreases the camber of the elevator and creates a downward aerodynamic force
         - Overall Effect
           - a Causes the tail of the airplane to move down and the nose to pitch up
           - b Pitching moment occurs about the CG
             1. Strength of pitching moment depends on distance between CG and horizontal tail surface
       - b. Forward pressure
         - Deflects the trailing edge of the elevator surface down
           - a Increases the camber, creating more lift (less tail down force)
         - Overall Effect
           - a Causes the tail to move upward and pitches the moment down
           - b The pitching moment occurs around the CG
   - C. Roll
     - i. Controlled by the ailerons
       - a. Controls to the right
         - Right aileron deflects up, decreasing the camber, resulting in decreased lift on the right wing
         - Left aileron deflects down, increasing the camber, resulting in increased lift on the left wing

- a The increased lift on the left wing and the decreased lift on the right wing causes the airplane to roll to the right

b. Controls to the left
- Left aileron deflects up, decreasing the camber, resulting in decreased lift on the left wing
- Right aileron deflects down, increasing the camber, resulting in increased lift on the right wing
  - a The increased lift on the right wing and the decreased lift on the left wing causes the airplane to roll to the left

D. Yaw

i. Controlled by the rudders

ii. When the rudder is deflected in one direction, a horizontal force is produced in the opposite direction

a. Pushing the left pedal yaws the nose of the plane to the left
- The rudder deflects to the left and produces a sideward lift to the right
- The rudder moves left, the sideward lift moves the tail to the right, and the nose yaws left

b. Pushing the right pedal yaws the nose of the plane to the right
- The rudder deflects to the right and produces a sideward lift to the left
- The rudder moves right, the sideward lift moves the tail to the left, and the nose yaws to the right

2. Control Pressures & Trim AI.VIII.A.K2

A. Control Pressures

i. It is important to maintain a light grip on the flight controls

a. Only grip with the fingertips

ii. The control forces desired should be exerted lightly and just enough to produce the desired result

a. Large, jerky movements lead to large pitch, bank, airspeed changes, and chasing the desired attitude

b. Technique: Pay attention to the steering wheel corrections used to maintain a lane on the freeway
- Replicate this in the plane to – very small, smooth, and controlled pressures

c. The student should follow along with the instructor during the maneuver to feel the control pressures being used to maintain straight-and-level flight
- Demonstrates that little control movements are necessary
- The student becomes more confident through the procedures
- Show the student, then let the student fly

iii. Overcoming Tenseness/Over-controlling

a. Signs of over-controlling
- Control movements rather than control pressures
  - a Jolty, large movements of the flight controls
  - b White knuckles (look for the death grip)
  - c Overall nervousness

b. Prevention
- Point out the over-controlling and demonstrate the correct light, fingertip grip and the pressures desired
- If over-controlling is consistent, place a wooden pencil on top of the middle and ring finger and under the index and pointer finger of the hand the student uses to fly
  - a If the student starts the death grip, the force of the pencil on his middle/ring finger will remind them to relax, if the student continues to tighten their grip the pencil will break

B. Trim Technique

i. Most planes are designed so that the primary flight controls (rudder, aileron, elevator) are streamlined with the non-movable airplane surfaces when the airplane is cruising straight and level at normal weight and loading

a. Outside of that balanced condition (faster, slower, heavier, lighter, etc.), one or more of the control

surfaces is going to have to be held out of its streamlined position by continuous control input
- Trim tabs/control surfaces offset the constant flight control pressure inputs needed from the pilot

b. Proper trim is an indication of good piloting skills, and should allow the pilot to fly almost hands free
   - a Any control forces felt should be a result of deliberate flight control inputs

c. An improperly trimmed aircraft:
- Requires constant flight control pressures
- Produces tension and fatigue
- Distracts the pilot from visual scanning
- Contributes to abrupt and erratic airplane control inputs

ii. Trimming the Airplane

a. Steps
- Set the power
- Set the pitch
- Let the airspeed stabilize
- Trim the airplane for the current airspeed

b. Method
- Using the primary flight controls, establish and hold the desired attitude
   - a Establish with reference to the horizon and verify by reference to the flight instruments
- Apply trim to relieve the control pressure
   - a Most GA aircraft only have elevator trim, although some also have rudder and aileron trim
      1. With multiple trim tabs, trim the rudder, then elevator, then aileron
- If power changes, the attitude for level flight will change, and the aircraft will have to be re-trimmed
   - a On a longer flight, as the CG changes with decreasing fuel, small adjustments must be made to maintain proper trim

c. Don't fly the airplane with trim is a common fault

d. Consistently make small adjustments to remain trimmed for level flight

3. Integrated Flight Instruction AI.VIII.A.K4

A. Use of outside references and instruments to establish and maintain flight attitudes and airplane performance

i. Students who learn this way achieve a more precise and competent overall piloting ability

ii. The pilot should become familiar with the relationship between outside visual references and the corresponding instrument indications

a. Ex: A pitch adjustment may require a movement of several inches in relation to the natural horizon, but a seemingly insignificant movement on the attitude indicator

B. The Basic Elements

i. 90% outside, 10% inside

a. At least 90% of the pilot's attention should be devoted to outside visual references and scanning for other traffic

ii. Validate the airplane's attitude on the flight instruments

a. If the instruments display that the airplane's performance needs a correction, determine the correction and then apply it with reference to the natural horizon

b. The airplane's attitude and performance are then rechecked by referring to the flight instruments

c. Then maintain the corrected attitude by reference to the natural horizon

iii. Quick snap shots of the instruments

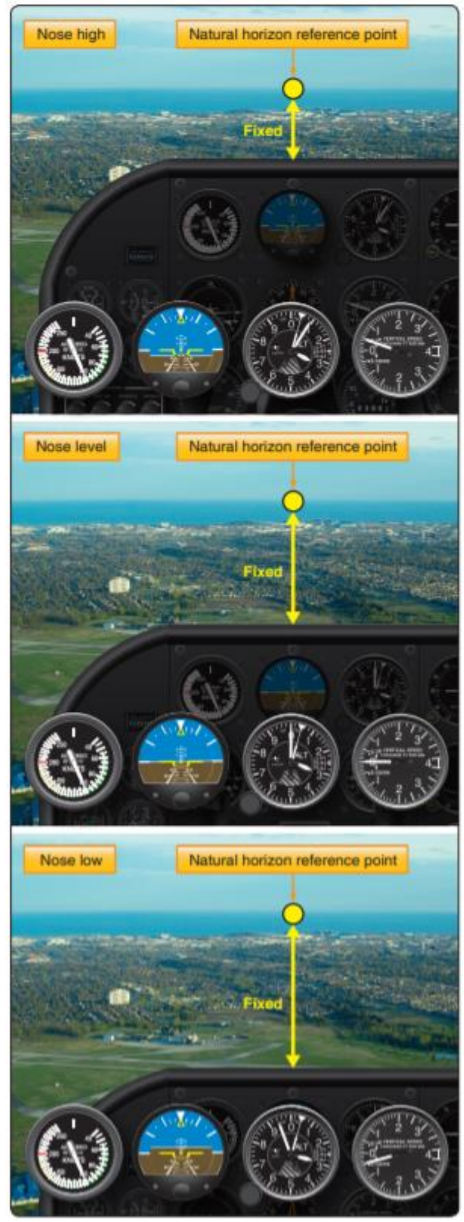
a. No more than 10% of the pilot's attention should be inside the flight deck

b. The pilot must learn to focus quickly on the appropriate flight instruments and then return immediately to the outside visual references

4. Straight and Level Flight AI.VIII.A.K1

A. Overview
   i. Straight and level flight is a matter of consciously fixing the relationship of a reference point on the airplane in relation to the natural horizon
      a. Vertical reference lines are best established on the ground
      b. Horizontal reference lines are best established in flight
      c. Ensure the pilot is properly seated to maintain and establish the reference points
   ii. The objective is to detect small deviations from level flight as soon as they occur, necessitating only small corrections

B. Level Flight AI.VIII.A.K3



   i. Fix the relationship of the position of a portion of the airplane (toward the nose), used as a reference point, with the horizon
      a. Intent is to learn to associate the movement of references with the accompanying forces and resulting performance
   ii. Pitch (Constant Altitude)
      a. Outside AI.VIII.A.K3
         - Select a portion of the nose or glare shield as a reference point and keep it in a fixed position relative to the horizon
      b. Inside
         - To determine whether the pitch attitude is correct, occasionally crosscheck outside reference (90% outside, 10% inside) against:
            a The altimeter: To check actual altitude
            b The attitude indicator: To show the position of the nose in relation to the horizon
            c VSI: To show any trends forming
            d Airspeed Indicator
               1. Faster airspeed = Descending
               2. Slower airspeed = Climbing
      c. Corrections (Control Procedure)
         - If altitude is being lost or gained, the pitch attitude should be readjusted in relation to the horizon, then the altimeter should be checked to determine altitude is being maintained
         - Elevators are the control
            a Forward or back elevator pressure is used to control the pitch attitude
               1. Increasing pitch attitude (back pressure) raises the nose in relation to the horizon
               2. Decreasing pitch attitude (forward pressure) lowers the nose in relation to the horizon
         - Note the relationship between control pressure and the airplane's change in attitude
            a Use small, smooth controlled movements to maintain level flight

C. Straight Flight
   i. As with level flight, straight flight is accomplished by maintaining a visual reference. Rather than using the nose, for straight flight we use the position of the wings relative to the horizon
   ii. Bank (Constant Heading)
      a. Outside AI.VIII.A.K3

- Both wingtips should be level and equally above or below the horizon (high wing versus low wing)
- Select two or more visual reference points directly ahead of the plane (roads, lakes, towers, etc.)
  - a Form an imaginary line between them and keep the airplane headed along that line
    1. If the points move out of alignment, correct to realign them
  - b Like the site on a gun
    1. Line up the 'V' with the point at the end of the barrel

b. Inside
- To determine whether bank attitude is correct, outside references should be cross checked against:
  - a The heading indicator: To determine that the desired heading is maintained
  - b The attitude indicator: To ensure the wings are level
  - c Turn Coordinator: To ensure coordination and that the aircraft is not unintentionally in a turn
  - d Magnetic Compass: To ensure desired heading is maintained & the heading indicator is correct
  - e Ensure coordinated use of ailerons and rudder

c. Corrections (Control Procedure)
- If the airplane is banking in one direction or the other, the bank should be readjusted to put both wings an equal distance from the horizon
- Ailerons are the control
  - a Right aileron pressure (turns right) results in the left wing raising and right wing lowering
  - b Left aileron pressure (turns left) results in the right wing raising and the left wing lowering
- Note the relationship between control pressure and the airplane's change in attitude
- As mentioned in level flight, use small, smooth controlled movements

D. Power

i. The airplane's airspeed remains constant in straight and level flight if the power setting is also constant

ii. Outside

a. Changes in power settings, and/or airspeed will require changes in pitch attitude to maintain altitude

iii. Inside

a. Cross check changes in airspeed with the Engine RPM and/or manifold pressure gauges
- Increased power will result in a climb if no changes are made to the pitch attitude
- Decreased power will result in a descent if no pitch changes are made to the pitch attitude

iv. Corrections (Control Procedure)

a. As power is increased or decreased pitch attitude must be adjusted
- As power is increased, and airspeed increases, progressively decrease pitch to maintain altitude
  - a When acceleration ceases, and the plane is level, note the new horizon reference
- If power is decreased, and airspeed decreases, progressively increase pitch to maintain altitude

a Once deceleration ceases, and the plane is level, note the new horizon reference

5. Common Errors AI.VIII.A.K5

A. Attempting to use improper pitch and bank references.
B. Forgetting the location of preselected reference points on subsequent flights.
C. Attempting to establish or correct airplane attitude using flight instruments rather than the natural horizon.
D. "Chasing" the flight instruments rather than adhering to the principles of attitude flying.
E. Mechanically pushing or pulling on the flight controls rather than exerting accurate and smooth pressure.
F. Not scanning outside the aircraft for other traffic and weather and terrain influences.
G. A tight palm grip on the flight controls resulting in a desensitized feeling of the hand and fingers.
H. Overcontrolling the airplane.
I. Habitually flying with one wing low or maintaining directional control using only the rudder control.
J. Failure to make timely and measured control inputs after a deviation from straight-and-level.
K. Inadequate attention to sensory inputs in developing feel for the airplane to establish attitude.

6. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VIII. RM Concepts – Distractions, Task Prioritization, SA AI.VIII.A.R1
B. VIII. RM Concepts – Collision Hazards AI.VIII.A.R2

Conclusion:

Brief review of the main points

Level flight is maintained with pitch. We monitor pitch by keeping the reference point off the nose of the plane in the same place on the horizon and referencing the altimeter and attitude indicator. Straight flight is maintained through roll. We monitor bank by keeping an equal distance above (or below) each wing and the horizon, as well as maintaining a straight line between two points directly in front of the airplane. These visual references are cross checked with the heading indicator and attitude indicator. Trim is essential in relieving the control pressures necessary to maintain level flight. Trim frequently and in small amounts to maintain straight and level flight.

VIII.B. Level Turns

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of the elements related to establishing and maintaining a level turn.
Key Elements	1. Increased Back Pressure (HCL/VCL) 2. Coordination (Adverse Yaw) 3. Control *Pressures*
Elements	1. Flight Controls 2. How the Turn Works 3. Control Pressures & Trim Use 4. Integrated Flight Instruction 5. Level Turns 6. Common Errors 7. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Model Airplane
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can turn at varying degrees of bank, maintaining altitude and airspeed.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Level turns sound simple, but there is a lot more to turning than you might think, and a strong grasp on this will make many other maneuvers considerably easier.

Overview

Review Objectives and Elements/Key ideas

What

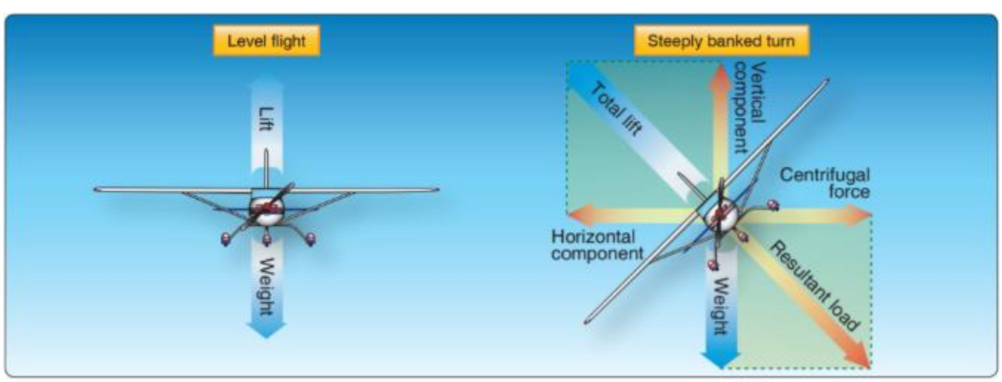
A turn at a specified angle of bank in which altitude and airspeed are maintained.

Why AI.VIII.B.K1

The ability to understand and fly a level turn is essential to the building of every pilot's skill set. Level turns are the building blocks to many more difficult maneuvers and will help the pilot in his or her control of the airplane.

How:

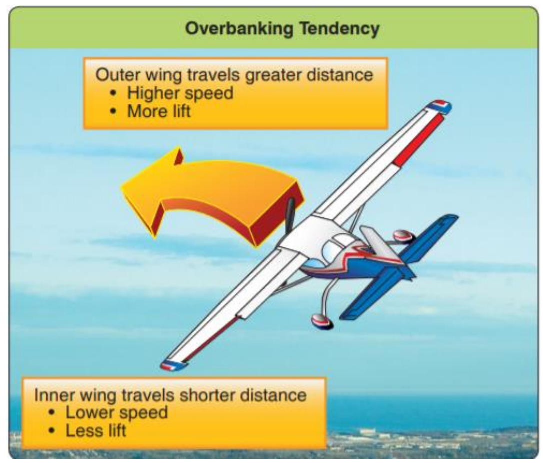
1. **Flight Controls**
    - A. All four primary controls are used in coordination when making turns
        - i. Ailerons - Bank the wings and determine the rate of turn at a given airspeed
        - ii. Elevator - Moves the nose up or down in relation to the pilot, and perpendicular to the wings
            - a. It sets the pitch attitude in the turn and "pulls" the nose around the turn
        - iii. Rudder - Offsets yaw effects developed by the other controls (is not used to turn the airplane)
        - iv. Throttle - Provides thrust which may be used to maintain airspeed during a turn
2. **How the Turn Works**
    - A. Changing the direction of the wing's lift to either side causes the airplane to be pulled that direction
        - i. This is done by applying coordinated aileron and rudder to bank the airplane
    - B. Lift
        - i. In straight and level flight, the total lift is acting perpendicular to the wings and the Earth
            - a. As the plane is banked, lift becomes the resultant of two components:
                - Vertical Component (VC) - Continues to act perpendicular to Earth and opposes gravity, or weight
                - Horizontal Component (HC) - Acts parallel to Earth's surface, opposes inertia (or Centrifugal Force)
            - b. The vertical and horizontal components act at right angles to each other (shown in the picture below); total lift acts perpendicular to the banked wings
                - The horizontal component of lift is what turns the airplane



    - ii. Since a portion of vertical lift has been shifted to horizontal lift, AOA must be increased to maintain altitude
        - a. Total lift must be increased to compensate for decreased vertical lift
        - b. Total lift is perpendicular to the banked wings

- C. Adverse Yaw
    - i. When ailerons are deflected, lift and drag are increased on the rising wing, and decreased on the lowering wing
        - a. Aileron on the rising wing deflects down producing more lift and therefore more induced drag
    - ii. The change in drag between the wings results in yaw in the opposite the direction of the turn (adverse yaw)
    - iii. To counter adverse yaw, rudder pressure is applied simultaneously with aileron in the direction of the turn

- D. Overbanking Tendency
    - i. As turn radius gets smaller, a significant difference develops between the speed of the inside wing and the outside wing
        - a. The wing on the outside travels a longer path than the inside wing in the same amount of time
            - Outside wing is faster & therefore develops more lift
            - The difference in lift between wings increases bank
        - b. Shallow bank: Difference in lift between the wings is generally overcome by the inherent lateral stability
            - Tendency to roll back to wings level unless the aileron is held in the direction of the turn
        - c. Medium bank: The lift differential generally matches the plane's inherent lateral stability characteristics
            - Aileron can be left neutral, bank will remain constant
        - d. High bank (usually > 45°): Difference in lift between the wings outweighs inherent lateral stability
            - Opposite aileron is required to maintain bank



- E. Rate of Turn
    - i. The rate of turn is dependent on airspeed and the horizontal component of lift (bank angle)
        - a. Horizontal Component of Lift (bank angle)
            - The rate of turn at a given airspeed is dependent on the horizontal component of lift
                - a The horizontal component of lift varies in proportion to the amount of bank
                    - 1. As bank angle increases, the horizontal component of lift increases
                    - 2. Therefore, the steeper the angle of bank, the higher the rate of turn
        - b. Airspeed
            - As airspeed increases, the aircraft's rate of turn decreases due to inertia
                - a The higher the airspeed of an aircraft, the greater the inertia
                    - 1. The greater the inertia, the more the aircraft desires to continue straight ahead and therefore the slower the rate of turn
                - b At a given angle of bank, a higher true airspeed will decrease rate of turn and increase radius
- F. Coordination
    - i. The ball in the turn and slip indicator will be displaced whenever the airplane is skidding or slipping
    - ii. In proper coordinated flight, there is no skidding or slipping
    - iii. Step on the ball to center it and maintain coordinated flight
        - a. Adverse yaw must be compensated for with rudder in the direction of the turn

        b. Anticipate and add rudder pressure with aileron
    iv. Uncoordinated flight results in decreased performance (excess drag)
        a. Reduces airspeed, climb ability, etc.

3. Control Pressures & Trim Use AI.VIII.B.K2

A. Control Pressures
- i. It is important to maintain a light grip on the flight controls
    - a. Only grip with the fingertips
- ii. The control forces desired should be exerted lightly and just enough to produce the desired result
    - a. Large, jerky movements lead to large changes in pitch, bank, airspeed, etc., which leads to the pilot chasing the desired attitude
    - b. Next time you drive, pay attention to the steering corrections used to maintain your lane on the freeway
        - Replicate this in the airplane – very small, smooth, and controlled pressures
    - c. Student should follow along to feel the control pressures used to maintain a level turn
        - Demonstrate that small control movements are sufficient/necessary for smooth/controlled flight
        - Student becomes more confident through the procedures
        - Demo/Do: Show the student, then let the student fly
- iii. Overcoming Tenseness/Over-controlling
    - a. Signs of over-controlling
        - Control movements rather than control pressures
            - a Jolty, large movements of the flight controls
            - b White knuckles (look for the death grip)
            - c Overall nervousness
    - b. Prevention
        - Point out the over-controlling and demonstrate the correct light, fingertip grip and the pressures desired
        - If over-controlling is consistent, place a wooden pencil on top of the middle and ring finger and under the index and pointer finger of the hand the student uses to fly
            - a If the student starts the death grip, the force of the pencil on his middle/ring finger will remind him/her to relax, if the student continues to tighten their grip the pencil will break

B. Trim Technique AI.VIII.B.K2
- i. Most airplanes are designed so that the primary flight controls (rudder, aileron, elevator) are streamlined with the non-movable surfaces when cruising in straight-and-level, while at normal weight and loading
    - a. If the airplane is out of the balanced condition (faster, slower, heavier, lighter, etc.), one or more of the control surfaces is going to have to be held out of its streamlined position by continuous control input
        - Trim tabs/control surfaces offset the constant flight control pressure inputs needed from the pilot
        - Proper trimming is an indication of good piloting skills, and should allow almost hands-free flight
            - a Any control forces felt should be from deliberate inputs, not forces applied by the airplane
        - An improperly trimmed aircraft requires constant control pressures from the pilot, produces tension and fatigue, distracts from visual scanning, and contributes to abrupt and erratic control inputs
- ii. Trimming the Airplane
    - a. Set the power
    - b. Set the pitch
    - c. Let the airspeed stabilize
    - d. Trim the airplane for the current airspeed
        - Method
            - a Establish and hold the airplane in the desired attitude using the primary flight controls
                1. Established with reference to the horizon and verify by reference to the flight instruments

- b Trim to relieve the control pressure
  1. Most GA aircraft only have elevator trim, although some also have rudder and aileron trim
     a. With multiple trim tabs, trim the rudder first, then elevator, then aileron
- c If power changes, pitch will change, and the aircraft will have to be re-trimmed
  1. On longer flights, as the CG changes with decreasing fuel, trim will have to be adjusted

e. Don't fly the airplane with trim

f. Consistently make small adjustments to remain trimmed for level flight

4. Integrated Flight Instruction AI.VIII.B.K4

A. Use of outside references and instruments to establish and maintain flight attitudes and airplane performance
- i. Students who learn this way achieve a more precise and competent overall piloting ability
- ii. Teaches the relationship between outside visual references and the corresponding instrument indications

B. Basic Elements
- i. 90% outside, 10% inside
  - a. At least 90% of the pilot's attention should be devoted to outside visual references & scanning for traffic
- ii. Validate the airplane's attitude on the flight instruments
  - a. If the instruments do not indicate the desired performance, determine the necessary correction and apply it with reference to the natural horizon
  - b. Verify the correction(s) had the desired effect by referring to the flight instruments
  - c. Maintain the corrected attitude by reference to the natural horizon
- iii. Quick snap shots of the instruments
  - a. No more than 10% of the pilot's attention should be inside the flight deck
  - b. Focus quickly on the appropriate instruments and then return to the outside visual references

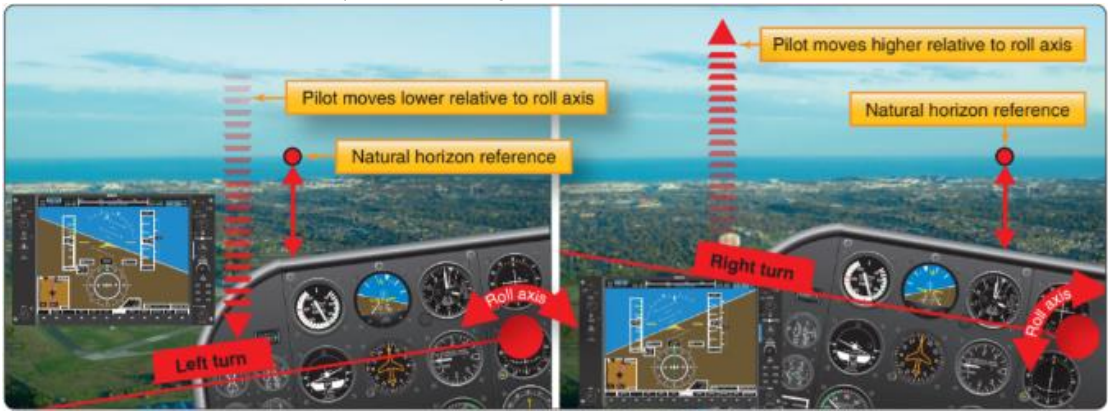
5. Level Turns AI.VIII.B.K1

A. Before turning, clear the area in the direction of the turn and complete the pre-maneuver checklist

B. Entering the Turn, Establishing the Bank Angle
- i. Outside References AI.VIII.B.K3
  - a. On most light single-engine airplanes, the top of the engine cowling is fairly flat, and its horizontal surface relative to the natural horizon provides a good indication for setting bank and pitch
    - The wings can also be used as a reference
    - Use the position of the cowling and/or wings on the horizon as your attitude indicator to establish the turn, then crosscheck with the instruments
    - With experience you will learn to associate the outside references with the required bank and pitch

  - b. Parallax Error
    - The airplane rolls on the longitudinal axis
    - With side-by-side seating, each pilot sits to one side of the longitudinal axis
    - In the left seat, this results in the nose appearing to rise in a left turn (due to the pilot lowering in relation to the longitudinal axis) and appearing to descend in a right turn (due to the pilot rising)

a Vice-versa for the pilot in the right seat



c. The pilot may lean away from the turn to remain in an upright position in relation to the horizon
   - This should be avoided and corrected immediately to properly use visual references

ii. Control Inputs AI.VIII.B.K2
   a. Aileron and rudder pressure should be input together
      - Use small, smooth flight control inputs
         a Provides time to evaluate and adjust to the changing attitude
         b The faster and more firmly the aileron is applied, the faster the roll
         c The longer the aileron pressure is held, the greater the bank angle
      - Maintain Coordination
         a Done properly, the nose should rotate on the horizon without leading or lagging the bank
         b The ball of the turn coordinator should remain centered
            1. "Step on the ball" to center it
            2. If the nose starts to move before the bank starts, rudder is being applied too early
            3. If bank starts before the nose starts turning, or the nose moves in the opposite direction, the rudder is being applied too late
   b. Elevator Pressure
      - As roll is established, and vertical lift is reduced, gently increase back pressure to hold level flight
         a The smaller the bank, the less elevator back pressure required, and vice-versa
         b When &how much back pressure to apply varies by aircraft, roll speed, weight, altitude, etc.
            1. Become familiar with the visual pitch references at different bank angles, and develop a feel for when the pitch input is required in the turn
      - If desired, trim to maintain hands free level flight, and reduce pilot workload
   c. Power
      - As lift is increased to maintain altitude in the turn, drag is also increased, reducing airspeed
         a Usually not significant for small bank angles
      - Increase power to maintain the desired airspeed
         a Generally necessary above 30° of bank

iii. Crosscheck – 90% outside, 10% inside
   a. Establish the turn with outside references
      - Bank – Angle of the engine cowling and/or wings relative to the horizon
      - Pitch – Height of the engine cowling or another point on the aircraft relative to the horizon
   b. Crosscheck with the instruments
      - Attitude indicator – Verify desired bank angle and pitch attitude
      - Turn Coordinator – Coordinated flight
      - Attitude Indicator – Should show level flight

- Vertical Speed Indicator – Should show zero climb. Check for trends
- Heading Indicator – Turning at a normal rate toward the desired heading
- Airspeed Indicator – Check for proper airspeed

C. In the Turn
  i. Reference the natural horizon, scan for traffic, and occasionally crosscheck the instruments
  ii. Outside References AI.VIII.B.K3
    a. Maintain the relationship between the cowling and/or wings and horizon, while scanning for traffic
  iii. Control Inputs AI.VIII.B.K2
    a. Aileron and Rudder (Maintaining Bank)
      - Low bank: Maintain aileron and rudder pressure in the direction of the turn
      - Medium bank: The pilot can relax the controls
      - High bank: Apply opposite aileron and rudder to maintain bank and prevent it from steepening
      - Adjust as required using smooth, and controlled *pressures* throughout the turn
    b. Elevator Pressure (Maintaining Altitude)
      - Back pressure on the elevator should not be relaxed
        a The vertical component of lift must be maintained if altitude is to be maintained
      - Adjust trim to maintain hands free level flight
    c. Power (Maintaining Airspeed)
      - If properly set when the turn was established, the power should remain the same through the turn
      - If the airspeed has increased/decreased 3-5 knots, adjust the power
  iv. Crosscheck and Adjust – 90% outside, 10% inside
    a. Same as above - backup the outside references with the instruments and ensure bank, altitude, coordination and airspeed are maintained
    b. Adjustments
      - If bank angle is too high or low, use the ailerons to correct it
        a Adjust rudder to maintain coordination
      - If climbing/descending, adjust pitch in relation to the horizon, then check the altimeter/VSI
        a Once the proper attitude is verified, maintain it with visual references
      - Trim the airplane
  v. Summary
    a. During all turns, the ailerons, rudder and elevator correct minor variations in pitch and bank

D. Roll Out
  i. General/Control Inputs AI.VIII.B.K2
    a. Similar to a roll in except control pressures are used in the opposite direction
      - Aileron and rudder are applied toward the high wing
    b. Since the airplane continues to turn as long as there is any bank, the rollout must be started prior to reaching the desired heading
      - As a rule, lead the rollout by approximately ½ the bank angle (this is a very slow roll out)
        a In a 30° bank turn, start the rollout 15° before your desired heading
    c. As the bank decreases, elevator pressure should be gently relaxed to maintain altitude
      - Horizontal component of lift decreases and the vertical component increases
    d. Power should be reduced to maintain airspeed in straight flight
    e. As the wings become level, control pressures should be smoothly relaxed, so they're neutralized as the plane returns to straight-and-level flight
    f. Remove trim, if necessary
  ii. Outside: The aircraft should be returned to the straight-and-level flight references AI.VIII.B.K3
  iii. Crosscheck – 90% outside, 10% inside

a. Continue to reference the natural horizon, scan for traffic, and crosscheck the flight instruments

6. Common Errors AI.VIII.B.K5

A. Failure to adequately clear in the direction of turn for aircraft traffic.
B. Gaining or losing altitude during the turn.
C. Not holding the desired bank angle constant.
D. Attempting to execute the turn solely by instrument reference.
E. Leaning away from the direction of the turn while seated.
F. Insufficient feel for the airplane as evidenced by the inability to detect slips or skids without flight instruments.
G. Attempting to maintain a constant bank angle by referencing only the airplane's nose.
H. Making skidding flat turns to avoid banking the airplane.
I. Holding excessive rudder in the direction of turn.
J. Gaining proficiency in turns in only one direction.
K. Failure to coordinate the controls

7. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VIII. RM Concepts – Distractions, Task Prioritization, SA AI.VIII.B.R1
B. VIII. RM Concepts – Collision Hazards AI.VIII.B.R2

Conclusion:

Brief review of the main points

In a level turn, we establish and maintain bank and pitch in relation to the horizon. The airplane's attitude is confirmed by referring to flight instruments. If performance, as indicated by flight instruments, requires a correction, we adjust pitch and bank by visual references and again confirm performance with the instruments. 90% outside, 10% inside.

VIII.C. Straight Climbs & Climbing Turns

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of straight and turning climbs. The learner will demonstrate the ability to perform a constant airspeed climb during straight flight as well as in a turn. The learner will learn the effects of climbs and be able to keep the airplane coordinated throughout.
Key Elements	1. Increased Thrust 2. Coordination 3. Crosschecking
Elements	1. Flight Controls 2. Forces in the Climb 3. Types of Climbs 4. Control Pressures & Trim Use 5. Integrated Flight Instruction 6. Straight Climb 7. Climbing Turn 8. Common Errors 9. Hazards
Schedule	1. Discuss Objectives 2. Review Material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss Lesson Objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign Homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can maintain a constant airspeed climb while maintaining coordination. The learner notices changes and properly corrects for them by using outside references and crosschecking them with the instruments.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

As simple as a climb sounds, the climb is a building block of your flying future. The knowledge and skill learned here will make more complicated maneuvers easier.

Overview

Review Objectives and Elements/Key ideas

What

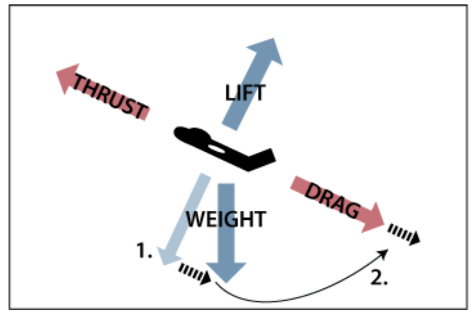
In straight and climbing turns the airplane is put into a climb attitude to gain altitude. The pitch and airspeed of the airplane are maintained together to accomplish the climb.

Why AI.VIII.C.K1

Climbs and climbing turns are part of the basis for all flying. By developing the skills necessary for basic climbs and climbing turns the pilot will lay the groundwork for many future maneuvers.

How:

1. **Flight Controls**
   - A. All four primary controls are used in coordination when making climbs and climbing turns
     - i. Ailerons - Bank the wings and determine the rate of turn at a given airspeed
     - ii. Elevator - Moves the nose up or down in relation to the pilot, and perpendicular to the wings
       - a. It sets the pitch attitude in the turn and "pulls" the nose around the turn
     - iii. Rudder - Offsets yaw effects developed by the other controls (is not used to turn the airplane)
     - iv. Throttle - Provides thrust which may be used to maintain airspeed during a turn
2. **Forces in the Climb**
   - A. Forces of Flight
     - i. Summary
       - a. In a climb, weight no longer acts perpendicular to the flightpath
         - It acts in a rearward direction (pointing toward the center of the Earth)
           - a This causes an increase in total drag requiring an increase in thrust to balance the forces
       - b. An airplane can only sustain a climb angle when there is sufficient thrust to offset increased drag
         - Therefore, climb is limited by the available thrust
     - ii. More Specific
       - a. In a normal, steady state climb, the wing's lift is the same as in level flight at the same airspeed
         - Although the flight path changed when the climb was established, the AOA of the wing with respect to the inclined flight path reverts to practically the same values, as does lift
       - b. In the change from straight and level to a climb, lift changes when elevator is first applied
         - Raising the nose increases the AOA and momentarily increases lift
         - Lift for this moment is greater than weight and the airplane starts climbing
       - c. Once the flight path is stabilized, AOA and lift revert to approximately level flight values
       - d. If there is no change in power, airspeed diminishes
         - A component of weight acts in the same direction & parallel to drag (1. In the picture)



- Drag > thrust and speed decreases until drag = thrust (2. in the picture)

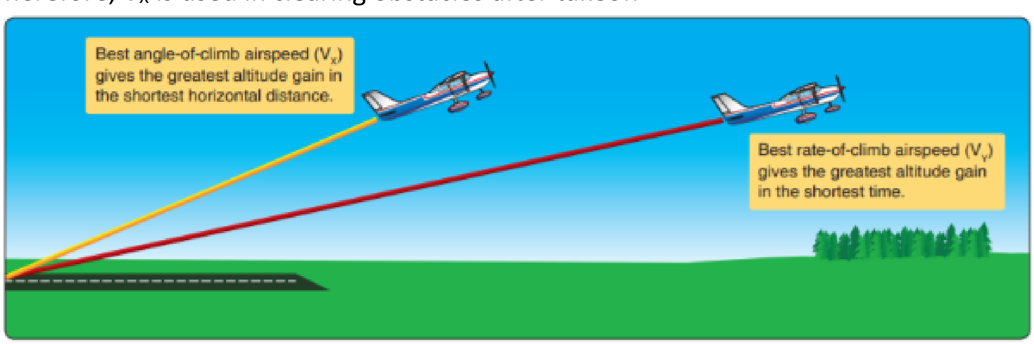
e. Since weight is acting downward & rearward with drag, more power is needed to maintain speed (the amount of power required depends on the angle of climb)
- Therefore, the aircraft's ability to climb is limited by available, or excess, thrust
- When excess thrust is gone, the climb stops (aircraft's absolute ceiling)

B. Propeller Effects
i. In a climb, propeller speed is significantly lower, and the AOA is significantly greater than in cruise
a. Torque and asymmetrical loading of the propeller will cause the airplane to roll, and yaw left
- Right rudder pedal pressure is necessary to counteract this

3. Types of Climbs

A. The pilot should know the engine power settings, natural horizon pitch attitudes, and flight instrument indications that produce the following types of climbs:
B. Normal Climb (Cruise Climb)
i. Performed at an airspeed recommended by the airplane manufacturer
a. Usually faster than the best rate of climb, but provides better cooling, control, and visibility
ii. *When we pitch for 75 or 90 knots in the DA20
C. Best Rate of Climb (V_Y)
i. Performed at the airspeed producing the most altitude gain in the least time (max feet per minute)
a. Airspeed where the most excess *power* is available over that required for level flight
- Power is the energy the engine produces

ii. As altitude increases, the airspeed for the best rate of climb decreases
iii. The best rate of climb speed + maximum power = the aircraft's maximum climb
a. Attempts to get more climb performance by increasing pitch results in a decreased rate of climb
D. Best Angle of Climb (V_X)
i. Performed at an airspeed that will produce the most altitude gain in the shortest distance
a. Slower than V_Y
ii. Airspeed where the most excess t*hrust* is available over that required for level flight
a. Thrust is what propels the airplane (the displaced air as a result of the spinning propeller)
iii. As altitude increases, the airspeed for the best angle of climb increases
iv. Read Thrust vs Power (on medium.com) for a short article breaking down the two terms
v. V_X will result in a steeper climb path, but will take longer to reach altitude than a climb at V_Y
a. Therefore, V_X is used in clearing obstacles after takeoff



4. Control Pressures & Trim Use AI.VIII.C.K2

A. Control Pressures

- i. It is important to maintain a light grip on the flight controls
  - a. Only grip with the fingertips
- ii. The control forces desired should be exerted lightly and just enough to produce the desired result
  - a. Large, jerky movements lead to large changes in pitch, bank, airspeed, etc., which leads to the pilot chasing the desired attitude
  - b. Next time you drive, pay attention to the steering wheel corrections you use to maintain your lane on the freeway
    - Replicate this in the airplane – very small, smooth, and controlled pressures
  - c. The student should follow along with the instructor during the maneuver to feel the control pressures being used to maintain straight-and-level flight
    - Demonstrates that little control movements are necessary
    - The student becomes more confident through the procedures
    - Show the student, then let the student fly
      - a Continue to make corrections as necessary
- iii. Overcoming Tenseness/Over-controlling
  - a. Signs of over-controlling
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B. Trim Technique
- i. Most planes are designed so the primary flight controls are streamlined with the non-movable surfaces when cruising straight & level at normal weight / loading
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- ii. Trimming the Airplane
  - a. Set the power
  - b. Set the pitch
  - c. Let the airspeed stabilize
  - d. Trim the airplane for the current airspeed
    - Method
      - a Establish and hold the airplane in the desired attitude using the primary flight controls
        1. Establish with reference to the horizon and verify with the flight instruments
      - b Apply trim to relieve the control pressure
        1. In airplanes with multiple trim tabs, trim the rudder, then elevator, then aileron

- c. If power changes, pitch changes, and the aircraft will have to be re-trimmed
  1. As the CG changes with decreasing fuel, small adjustments may have to be made
- iii. Don't fly the airplane with trim
- iv. There is no perfect trim - Consistently make small adjustments

5. Integrated Flight Instruction AI.VIII.C.K4

- A. Use of outside references & flight instruments to establish and maintain flight attitudes/performance
- B. The Basic Elements
  - i. 90% outside, 10% inside
    - a. At least 90% of attention should be devoted to outside references and scanning for other traffic
  - ii. Validate the airplane's attitude on the flight instruments
    - a. If the instruments display that the airplane's performance needs a correction, determine the correction, and then apply it with reference to the natural horizon
    - b. Attitude and performance are then rechecked by referring to the flight instruments
    - c. Maintain the corrected attitude by reference to the natural horizon
  - iii. Quick snap shots of the instruments
    - a. No more than 10% of the pilot's attention should be inside the flight deck
    - b. Focus quickly on the appropriate instruments and return immediately to the outside visual references

6. Straight Climb AI.VIII.C.K1, AI.VIII.C.K2

- A. Entering the Straight Climb
  - i. Gently increase back pressure to raise the nose in relation to the horizon, while simultaneously increasing engine power to the climb power setting, then verify with the instruments
    - a. As a climb is started, airspeed will gradually diminish if additional power is not provided
      - Reduction in speed is gradual because of the initial momentum of the airplane
      - As airspeed decreases, pitch tends to lower without increased back elevator pressure
    - b. In many airplanes, as power is increased, an increase in slipstream over the horizontal stabilizer will cause the nose to rise (creates a greater tail down force, lifting the nose)
      - Anticipate it, don't let it surprise you. Maintain pitch in relation to the horizon

  - ii. As power and pitch increase, increase right rudder pressure to counter left turning tendencies
    - a. More info in lesson II.D. Principles of Flight
  - iii. Use nose-up trim to maintain the climb pitch attitude without having to hold back elevator pressure
  - iv. Visual References AI.VIII.C.K3
    - a. Very similar to straight-and-level
      - Pitch: Visually establish the pitch attitude for the climb and maintain it in reference to the horizon
      - Straight Flight: Keep wingtips level relative to the horizon
        - a. Select two or more visual reference points directly ahead of the plane (roads, lakes, towers, etc.)
          1. Form an imaginary line between them and keep the airplane headed along that line
          2. If the points move out of alignment, realign them
- B. Maintaining the Straight Climb
  - i. Since power is fixed at the climb power setting, airspeed is controlled with elevator pressure
    - a. If too fast, raise the nose, let the airspeed stabilize, and trim

b. If too slow, lower the nose, let the airspeed stabilize, and trim
c. The amount of elevator pressure/pitch change depends on the change in speed
- Larger speed changes require larger movements
- Crosscheck for the desired results on the instruments
  a Attitude Indicator – Should indicate the approximate pitch required for the climb
  b Airspeed Indicator – Should indicate the desired climb airspeed
  c Heading Indicator – Should maintain the entry heading
  d Turn Coordinator – Should be centered indicating a coordinated climb

ii. Keep the wings level to maintain the heading
a. Use the same procedures as discussed in Straight-and-Level flight to visually maintain a heading
b. If off heading, use a bank angle equal to the degrees off to correct back
- Ex: If 10º off heading, use a gentle 10º bank angle to return to the original heading

iii. 90% outside, 10% inside AI.VIII.C.K3
a. Adjust relative to the horizon and verify with the instruments


C. Returning to Straight-and-Level Flight AI.VIII.C.K3
i. Initiate the level off at approximately 10% of the rate of climb
a. Ex: if climbing at 500 fpm, the level off should begin 50’ prior to the desired altitude
ii. Lower the nose smoothly and slowly to allow airspeed to increase
a. A loss of altitude will result if pitch is changed too rapidly without allowing airspeed to increase
iii. Gently lower the nose to the level flight pitch attitude on the horizon while maintaining wings level
a. Crosscheck pitch attitude with the instruments to ensure straight-and-level
iv. Temporarily leave power at the climb setting to accelerate to cruise speed
v. Reaching the desired cruise speed, adjust power to the cruise setting
a. Reduce right rudder pressure as power is reduced and the nose is lowered
- Watch the nose on the horizon to recognize undesired yaw, verify with instruments

vi. Trim for level flight

7. Climbing Turn AI.VIII.C.K1, AI.VIII.C.K2

A. Factors to Consider in a Climbing Turn vs a Straight Climb:
i. Additional back pressure & power is required to compensate for increased drag & reduced lift
ii. Bank Angle
a. It is most effective to limit the turns to shallow bank angles
- Provides for a more efficient rate of climb
- In medium or steep banked turns, climb performance is degraded, or possibly non-existent

b. At a constant power setting, the plane will climb at a slightly shallower angle when turning versus level because some of the lift is being used to turn the plane
c. Bank should always remain constant

iii. Adverse Yaw

a. Adjust rudder to compensate for left turning tendencies and the added adverse yaw
   - Left turn: Less right rudder pressure is required than in a straight climb
      - a Left turning tendencies are somewhat counteracted by adverse yaw pulling right
   - Right turn: More right rudder pressure is required than in a straight climb
      - a Left turning tendencies are amplified by the adverse yaw which is also pulling left

iv. All factors affecting the plane during level turns also affect it during climbing turns
   a. The pilot must manage stability, overbanking tendencies, adverse yaw, propeller effects, reduction of the vertical component of lift, and increased drag

B. Entering the Climbing Turn
   i. Climbing turns may be established in one of two ways:
      a. Enter the climb first and then bank into the turn
      b. Simultaneously establish the climb and turn
   ii. The procedure
      a. In both cases, position the nose and wings in relation to the horizon while increasing power
      b. Anticipate and add the right rudder to maintain coordination
      c. Crosscheck the attitude with the instruments and correct as required
      d. While maintaining the bank and coordination, trim to maintain pitch attitude/climb airspeed

C. Maintaining the Climbing Turn
   i. Maintain a constant bank angle and pitch attitude
   ii. Combine the level turns and straight climb references AI.VIII.C.K3
      a. Pitch is maintained in relation to the horizon as in a straight climb
         - Make adjustments relative to the horizon with the elevators & cross check the instruments
      b. Bank is maintained in relation to the angle of the cowling/wings and the horizon
         - Crosscheck with the attitude indicator and turn coordinator
         - When making changes, adjust bank with visual references, and crosscheck the instruments
      c. As pitch or bank are corrected, the other may need adjusted
   iii. Trim often to reduce pilot workload

D. Returning to Straight-and-Level Flight
   i. Opposite of the entry into the climbing turn
   ii. Smoothly/slowly lower the nose while rolling wings level to establish the straight-&-level site picture
      a. Divide attention between both pitch and bank
      b. Attempt to level the nose and wings simultaneously
         - Initially it may be easier to break the maneuver into lowering the nose, then rolling out the bank (or vice versa), in time work to manage both pitch and bank simultaneously
   iii. Maintain climb power to accelerate to the cruise airspeed, then reduce the throttle
   iv. As the nose is lowered, bank is removed, and power reduced, adjust rudder for coordination
   v. Once stabilized, trim for straight-and-level flight

8. Common Errors AI.VIII.C.K5

A. Attempting to establish pitch attitude by primarily referencing the airspeed indicator and chasing the airspeed.
B. Applying elevator pressure too aggressively resulting in an excessive climb angle.
C. Inadequate or inappropriate rudder pressure during climbing turns.
D. Allowing the airplane to yaw during climbs usually due to inadequate right rudder pressure.
E. Fixation on the airplane's nose during straight climbs, resulting in climbing with one wing low.
F. Initiating a climbing turn without coordinated flight controls, resulting in no turn and a climb with one wing low.
G. Improper coordination resulting in a slip that counteracts the rate of climb, resulting in little or no altitude gain.
H. Inability to keep pitch and bank attitude constant during climbing turns.
I. Attempting to exceed the airplane's climb capability.

J. Using excessive forward elevator pressure during level-off resulting in a loss of altitude or excessive low G-force

9. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VIII. RM Concepts – Distractions, Task Prioritization, SA AI.VIII.C.R1
B. VIII. RM Concepts – Collision Hazards AI.VIII.C.R2

Conclusion:

Brief review of the main points

In a climb, thrust must be increased because weight is acting backward relative to the flight path, resulting in an increase in drag. To maintain the proper pitch attitude, the nose of the airplane must be held in the same place relative to the horizon. Adjustments are made by crosschecking the attitude indicator as well as Altimeter and VSI. During a climbing turn, due to the decreased vertical component of lift, the climb rate will be lower than in a straight climb. It is very important to keep any climb coordinated using rudder.

VIII.D. Straight Descents & Descending Turns

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The student should develop knowledge of the elements related to straight and turning descents and can maintain a constant airspeed descent in both situations.
Key Elements	1. Decreased Drag 2. Coordination 3. Crosschecking
Elements	1. Flight Controls 2. Forces in the Descent 3. Types of Descents 4. Control Pressures & Trim Use 5. Integrated Flight Instruction 6. Straight Descents 7. Turning Descents 8. Common Errors 9. Hazards
Schedule	1. Discuss Objectives 2. Review Material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present lecture 3. Ask and answer questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the factors related to descents and can properly perform a descent while in straight or turning flight.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Straight and turning descents are the final chapter of the fundamentals of flying. This, along with the other fundamentals, is what everything else in flying builds upon. Getting these maneuvers right will improve all future maneuvers.

Overview

Review Objectives and Elements/Key ideas

What

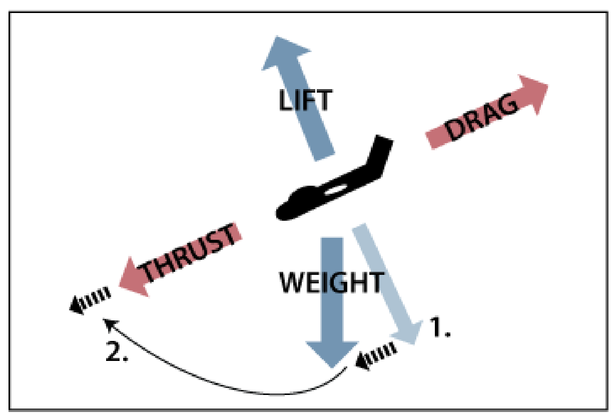
A descent is made when the aircraft is put in a configuration which will result in a loss of altitude.

Why AI.VIII.D.K1

Descents are a fundamental part of flight, understanding and being properly performing a descent will result in everything else being considerably easier.

How:

1. **Flight Controls**
   A. All four primary controls are used in coordination when making climbs and climbing turns
      i. Ailerons - Bank the wings and determine the rate of turn at a given airspeed
      ii. Elevator - Moves the nose up or down in relation to the pilot, and perpendicular to the wings
         a. It sets the pitch attitude in the turn and "pulls" the nose around the turn
      iii. Rudder - Offsets yaw effects developed by the other controls (is not used to turn the airplane)
      iv. Throttle - Provides thrust which may be used to maintain airspeed during a turn
2. **Forces in the Descent**



   A. In a descent, weight no longer acts perpendicular to the flightpath (light blue line in the picture)
      i. It acts in a forward direction (pointing toward the center of the earth – #1 In the picture)
         a. This effectively adds to thrust (#2 in the picture) which means a decrease in thrust (or increase in drag) is required to maintain airspeed in the descent
            - Ignoring drag devices, airspeed will increase if thrust is not decreased entering a descent
      iii. More Specific
         a. In a normal, steady state descent the wing's lift is the same as in level flight at the same airspeed
            - Although the flight path changed when the descent was established, the AOA of the wing with respect to the declined flight path reverts to practically the same values, as does lift
         f. Changing from straight-and-level to a descent, changes lift when elevator is first applied
            - Lowering the nose decreases the AOA and momentarily decreases lift
            - Lift at this moment is less than weight and the airplane starts descending
         g. Once the flight path is stabilized, the AOA and lift revert to approximately level flight values

h. If the descent is entered with no change in power, airspeed gradually increases
   - This is because the forward component of weight effectively adds to thrust
   - When declined, a component of weight acts in the same direction & parallel to thrust
     a #1 in the picture
     b Thrust is greater than drag and airspeed increases until drag = thrust (#2 in the picture)

i. Less power is needed to maintain the same airspeed as in level flight

3. Types of Descents

A. Partial Power Descent
   i. The normal method of losing altitude is to descend with partial power
      a. Use airspeed and power setting recommended by the manufacturer
   ii. Target descent rate should be 500 fpm (this will vary based on aircraft)

B. Descent at Minimum Safe Airspeed
   i. Nose-high, power assisted descent primarily used for clearing obstacles on a short field approach
      a. Airspeed is usually recommended by the manufacturer and is normally no greater than 1.3 V_{SO}
   ii. Characteristics
      a. Steeper than normal descent angle
      b. Excessive power may be necessary to accelerate should an excessive descent develop

C. Emergency Descent
   i. Some airplanes have a specific procedure for rapidly losing altitude in the POH
   ii. In general, emergency descents are high drag, high airspeed procedures requiring a specific configuration and speed, and often involve turns (increase descent and allow for clearing below)

D. Glide
   i. A basic maneuver in which the airplane loses altitude in a controlled descent with little or no power
      a. Descent rate is controlled by balancing the forces of gravity and lift
   ii. Clear the engine when operating in a power off condition for an extended period of time

4. Control Pressures & Trim Use AI.VIII.D.K2

A. Control Pressures
   i. It is important to maintain a light grip on the flight controls
      a. Only grip with the fingertips
   ii. The control forces desired should be exerted lightly and just enough to produce the desired result
      a. No jerky movements
   iii. Overcoming Tenseness/Over-controlling
      a. Signs of over-controlling
         - Control movements rather than control pressures
           a Jolty, large movements of the flight controls
           b White knuckles (look for the death grip)
           c Overall nervousness
      b. Prevention
         - Point out over-controlling and demo the correct light, fingertip grip and the pressures desired
         - If over-controlling is consistent, place a wooden pencil on top of the middle and ring finger and under the index and pointer finger of the hand the student uses to fly
           a If the student starts the death grip, the force of the pencil on his middle/ring finger will remind him/her to relax, if the student continues to tighten their grip the pencil will break

B. Trim Technique
   i. Most planes are designed so the primary flight controls are streamlined with the non-movable surfaces when cruising straight & level at normal weight / loading
      a. If the airplane is out of this balanced condition (faster, heavier, etc.), one or more of the control surfaces is going to have to be held out of its streamlined position by continuous control input

- Trim tabs/control surfaces offset the constant flight control pressure needed from the pilot
- Proper trimming is an indication of good piloting skills, allowing the pilot to fly almost hands free
    - a Any control forces felt should be deliberate flight control inputs
- Improper trim requires constant control pressure, produces tension and fatigue, distracts from visual scanning, and contributes to abrupt and erratic control inputs

ii. Trimming the Airplane
  a. Set the power
  b. Set the pitch
  c. Let the airspeed stabilize
  d. Trim the airplane for the current airspeed
    - Method
      - a Establish and hold the airplane in the desired attitude using the primary flight controls
        1. Establish with reference to the horizon and verify with the flight instruments
      - b Apply trim to relieve the control pressure
        1. Most GA aircraft only have elevator trim, although some also have rudder/aileron trim
           a. In airplanes with multiple trim tabs, trim the rudder, then elevator, then aileron
      - c If power changes, pitch changes, and the aircraft will have to be re-trimmed
        1. As the CG changes with decreasing fuel, small adjustments may have to be made

iii. Don't fly the plane with trim

iv. There is no such thing as the perfect trim - Consistently make small adjustments

5. Integrated Flight Instruction AI.VIII.D.K4

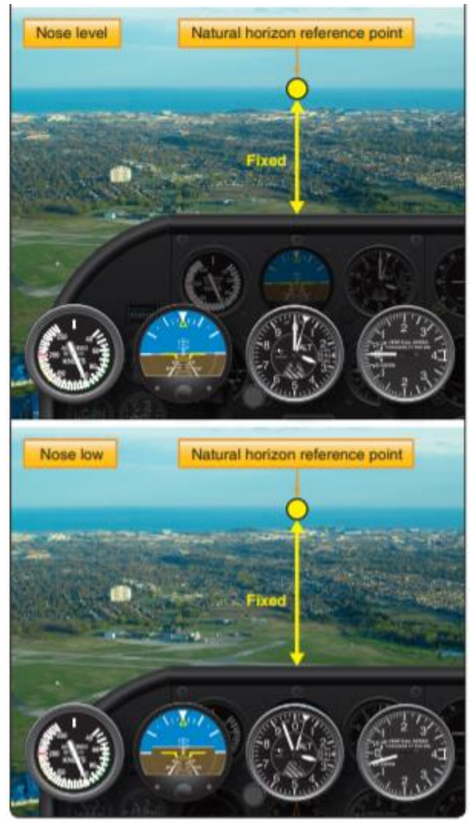
A. The use of outside references and flight instruments to establish and maintain desired flight attitudes and airplane performance

B. The Basic Elements
  i. 90% outside, 10% inside
  ii. Validate the airplane's attitude on the flight instruments
  iii. Quick snap shots of the instruments
    a. The pilot must learn to focus quickly on the appropriate flight instruments and then return immediately to the outside visual references

6. Straight Descents AI.VIII.D.K1, AI.VIII.D.K2

A. Entering the Straight Descent
  i. Slow to descent speed
    a. Gently decrease the power to the desired setting
    b. Maintain altitude until reaching the descent airspeed
      - As power is reduced, the nose will have a tendency to fall
        - a As power is decreased, a decrease in the slipstream over the horizontal stabilizer will cause the nose to fall (reduces the tail down force, lowering the nose)
      - Gently increase back pressure to maintain altitude and allow speed to gradually decrease
        - a The lower the power, the faster speed will decrease – a smooth, controlled power reduction allows the pilot to maintain altitude easier than a fast, large decrease in power

  ii. Establish the descent AI.VIII.D.K3
    a. Just prior to reaching descent airspeed, relax the back pressure to lower the nose to the approximate pitch attitude on the horizon for the descent
    b. Crosscheck the instruments



- If the airspeed is fast or slow, make a correction in relation to the natural horizon, let the airplane stabilize, and crosscheck again

iii. Trim the airplane
   a. Once stabilized in the descent at the desired speed, trim to relieve the control pressures

B. Maintaining the Descent AI.VIII.D.K3
   i. Throughout the descent, since power is fixed, airspeed is controlled by pitch (with elevator pressure)
      a. If airspeed is too fast, raise the nose relative to the horizon, let airspeed stabilize, and trim
      b. If too slow, lower the nose relative to the horizon, let airspeed stabilize, and trim
      c. The amount of elevator pressure/pitch change will depend on the required change in speed – larger speed changes require larger movements
         - Set the known pitch on the horizon and make small adjustments from there to obtain the desired airspeed
      d. Once at the desired airspeed, trim to relieve control pressures
   ii. Keep the wings level to maintain the straight descent
      a. Use the same procedures as discussed in Straight-and-Level flight to visually maintain a heading
         - Use the wings and nose of the airplane in relation to the horizon to maintain straight flight
         - Keep two points directly in line with each other in front of the airplane
      b. If off heading, use a bank angle equal to the degrees off to correct back
         - Ex: If 10° off heading, use a gentle 10° bank angle to return to the original heading
   iii. Maintain Coordination
      a. With reduced or idle power, the left turning tendencies are greatly reduced and therefore little, if any, rudder pressure will be required to maintain a straight descent
      b. Adverse yaw still exists - Maintain coordination during any turns with the turn coordinator
   iv. Crosscheck for the desired results on the instruments
      a. Attitude Indicator – Should indicate the approximate pitch attitude required for the descent
      b. Airspeed Indicator – Should indicate the descent airspeed
      c. Heading Indicator – Should maintain the entry heading
      d. Turn Coordinator – Should be centered indicating a coordinated descent
      e. 90% outside, 10% inside
         - Recognize the correction required, apply the correction outside, in relation to the horizon, and verify the result on the instruments. Trim the airplane for the new pitch attitude

C. Returning to Straight-and-Level flight
- i. Because of the downward inertia, the level off must be started before reaching the desired altitude
  - a. A general rule is to lead the level off by 10% of the descent rate
    - Ex: If descending at 1,000 fpm, start the level off 100’ prior to the desired altitude
- i. At the lead point, smoothly increase power to the cruise power setting, and begin to slowly raise the nose in relation to the horizon while maintaining wings level
  - a. Adding power at the lead point allows for a smooth acceleration to cruise speed
  - b. The nose tends to rise as airspeed and power increase
    - Keep an eye on the horizon, and adjust pitch as required for the level off
  - c. Use smooth, slow pressures to simultaneously reach the level flight attitude at the level off altitude
- ii. Establish the level flight site picture and allow the aircraft to accelerate to cruise speed
- iii. Once stable, trim for straight-and-level flight

7. Turning Descents AI.VIII.D.K1, AI.VIII.D.K2, AI.VIII.D.K3

A. Entering the Turning Descent
- i. Descending turns can be established one of two ways:
  - a. Enter the descent first and then bank into the turn
  - b. Enter the descent and turn simultaneously
  - c. Establish the desired bank angle with reference to the horizon and attitude indicator
- ii. The procedure
  - a. Very similar to the straight descent
  - b. Reduce the power and maintain altitude
  - c. Just prior to reaching the descent airspeed, enter the turning descent in one of the two ways
    - Lower the nose to establish the descent airspeed, and then roll into the desired bank
      - a Establish the pitch and roll in relation to the horizon then crosscheck the instruments
    - Lower the nose to establish the descent airspeed while rolling into the desired bank
      - a Establish in relation to the horizon and then crosscheck the instruments
  - d. Once at the desired airspeed and bank, note the nose and wings in relation to the horizon and the position on the attitude indicator
    - While maintaining pitch, bank, and coordination, trim to relieve the control pressures

B. Maintaining the Turning Descent
- i. Pitch adjustments are made in the same way as in a straight descent
- ii. Bank Adjustments
  - a. Increase or decrease bank as necessary to maintain the desired bank angle
  - b. Adjusting bank can affect airspeed and pitch will need to be adjusted
    - An increase in airspeed requires increased back pressure to maintain airspeed

- A decrease in airspeed requires a decrease in back pressure (forward pressure)

c. Trim to relieve the control pressures

iii. Maintain Coordination

a. Without power the left turning tendencies are greatly reduced

b. Adverse yaw still exists - Maintain coordination during the turn using the turn coordinator

iv. Crosscheck for the desired results on the instruments

a. Attitude Indicator – Should indicate the approximate pitch and bank required for the descent

b. Airspeed Indicator – Should indicate the descent airspeed

c. Heading Indicator – Should show a turn in the desired direction.

- Note the rate of movement – rapid movement can indicate a higher than desired bank angle

d. Turn Coordinator – Should be centered indicating a coordinated descent

e. 90% outside, 10% inside

- Recognize the correction required, apply the correction outside, in relation to the horizon, and verify the result on the instruments. Trim the airplane for the new pitch attitude

C. Returning to Straight-and-Level Flight

i. Very similar to the straight descent, except with the addition of rolling the wings level

ii. Lead the level off by 10% of the descent rate

iii. At the lead point, smoothly increase power for cruise, and slowly raise the nose/level the wings

a. Ensure attention is divide between pitch, bank, and coordination

iv. Attempt to level the nose and the wings simultaneously at the level off altitude

a. Initially, it may be easier to break the return to straight-and-level flight into two pieces – raising the nose, then rolling out the bank. Work to manage pitch and bank simultaneously

b. Adjust rudder pressure to maintain coordination as power is increased, and bank is rolled out

i. Once stabilized, trim the airplane for straight-and-level flight

8. Common Errors AI.VIII.D.K5

A. Failure to adequately clear for aircraft traffic in the turn direction or descent.

B. Inadequate elevator back pressure during glide entry resulting in an overly steep glide.

C. Failure to slow the airplane to approximate glide speed prior to lowering pitch attitude.

D. Attempting to establish/maintain a normal glide solely by reference to flight instruments.

E. Inability to sense changes in airspeed through sound and feel.

F. Inability to stabilize the glide (chasing the airspeed indicator).

G. Attempting to “stretch” the glide by applying back-elevator pressure.

H. Skidding or slipping during gliding turns and not recognizing the difference in rudder forces with/without power.

I. Failure to lower pitch attitude during gliding turn entry resulting in a decrease in airspeed.

J. Excessive rudder pressure during recovery from gliding turns.

K. Inadequate pitch control during recovery from straight glide.

L. Cross-controlling during gliding turns near the ground.

M. Failure to maintain constant bank angle during gliding turns.

9. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. VIII. RM Concepts – Distractions, Task Prioritization, SA AI.VIII.D.R1

B. VIII. RM Concepts – Collision Hazards AI.VIII.D.R2

Conclusion:

Brief review of the main points

Descents are part of the foundation of flying and are extremely important. As in all the fundamentals of flight, it is important to learn to fly the airplane by visual references and back those references up with the instrument indications.

VIII. RM Concepts

1. **Distractions, SA & Disorientation & Task Management**
   A. Distractions
      i. They're dangerous
         a. Can lead to slow speeds, unintended aircraft attitudes, collisions, disorientation, missed radio calls, etc.
         b. Remove distractions from your field of view or, in the case of a person, explain the situation and ask them to stop what they are doing
      ii. Sterile flight deck
         a. Maintain a sterile flight deck during taxi, takeoff, and climb as well as descent and landing
      iii. Fly first! Aviate, Navigate, Communicate
         a. Focus on the tasks at hand and stay ahead of the aircraft
         b. Ensure checklists have been completed, and both you and the aircraft are prepared for what's next
   B. Situational awareness (SA) & Disorientation
      i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
      ii. Maintain SA
         a. Starts with preflight planning
         b. Know what's coming next and stay ahead of the airplane
         c. Be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
         d. Divide attention between inside and outside references
         e. If SA is lost, admit it
            - If there's another pilot, let them take over while you catch up, if not, get the aircraft in a safe position (if landing, go around; if disoriented, trust the instruments and get to a safe attitude/altitude) and then solve the problem
      iii. Disorientation can be caused by, or lead to, an upset
         a. Push: Apply forward pressure to unload the plane
         b. Roll: Roll aggressively to the nearest horizon
         c. Thrust: Adjust as required
         d. Stabilize: Return to a safe flight condition
      iv. Lack of Visual References
         a. Can be very disorienting: Trust the instruments, use automation, ask for help, return to VMC
         b. For more details, see II.B. Visual Scanning & Collision Avoidance and II.M. Night Operations
   C. Task Management
      i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
         a. No one responsibility should take your full attention full more than a short period
      ii. Understand what tasks need to be accomplished and when
         a. Prioritize based on importance and time available
         b. Checklists and standard operating procedures are extremely helpful and enhance safety
      iii. Recognize when you are getting behind and find a way to catch up
         a. If more time is needed, find somewhere to hold/circle, or slow down
         b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
         c. "Attack the closest alligator" – Deal with the most pressing problem
      iv. Proper task management can help prevent distractions, loss of SA, and disorientation
      v. Safety is the number one priority – Aviate, Navigate, Communicate
2. **Collision Hazards**
   A. Collision Avoidance
      i. Scanning

a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
   - Each movement should not exceed 10º, each area should be observed for at least one second
b. Divide attention between flying and scanning for aircraft
   - Applicable in all phases of flight, especially important in high traffic areas

ii. Clearing Procedures
   a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
   b. Prior to any turn: Clear in the direction of the turn
   c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind

iii. Operation Lights On
   a. Voluntary FAA safety program to enhance the see and avoid concept
   b. Turn on landing lights during takeoff and when operating below 10,000', day or night
      - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected

iv. Right-of-Way Rules (FAR 91.113)
   a. An aircraft in distress has the right-of-way over all other traffic
   b. Converging Aircraft
      - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
      - If the aircraft are different categories:
         a Basically, the less maneuverable aircraft has the right-of-way
            1. Balloons, gliders, and airships have the right of way over airplanes
         b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
   c. Approaching Head-on: Each pilot shall alter course to the right
   d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
   e. Landing
      - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
         a Do not take advantage of this rule to force an aircraft off the runway which has already landed
      - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
         a Don't take advantage of this rule to cut in front of another aircraft

B. Terrain
   i. Plan well and be aware of terrain that could cause a hazard
      a. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
   ii. Day vs Night flying over terrain
      a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
      b. A personal minimum may be to only fly over high terrain during daylight
   iii. Minimum Safe Altitudes (FAR 91.119)
      a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
      b. Over Congested Areas: 1,000' above the highest obstacle within 2,000'
      c. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

C. Obstacles and Wire Strike
   i. Antenna Towers
      a. Numerous antennas extend over 1,000'-2,000' AGL
         - Most are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as guy wires can extend 1,500' horizontally from a structure
   ii. Overhead Wires (may not be lighted)
      a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
         - Lakes, highways, railroad tracks, etc.

PERFORMANCE & GROUND REFERENCE MANEUVERS

IX.A. Steep Turns

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of steep turns (load factors, torque, adverse yaw, and the overbanking tendency), and can perform a steep turn as required in the ACS.
Key Elements	1. Overbanking Tendency 2. Coordination 3. Increased back pressure and thrust 4. Maintain altitude with elevators and/or bank angle
Elements	1. Maximum Performance Turn 2. The Science Behind It 3. Performing the Steep Turn 4. Common Error 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the factors associated with a steep turn and can properly perform them in both directions, maintaining altitude and airspeed.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Steep turns – a really fun maneuver! Steep banks, you feel some Gs and you're staring at the ground out the side window!

Overview

Review Objectives and Elements/Key ideas

What

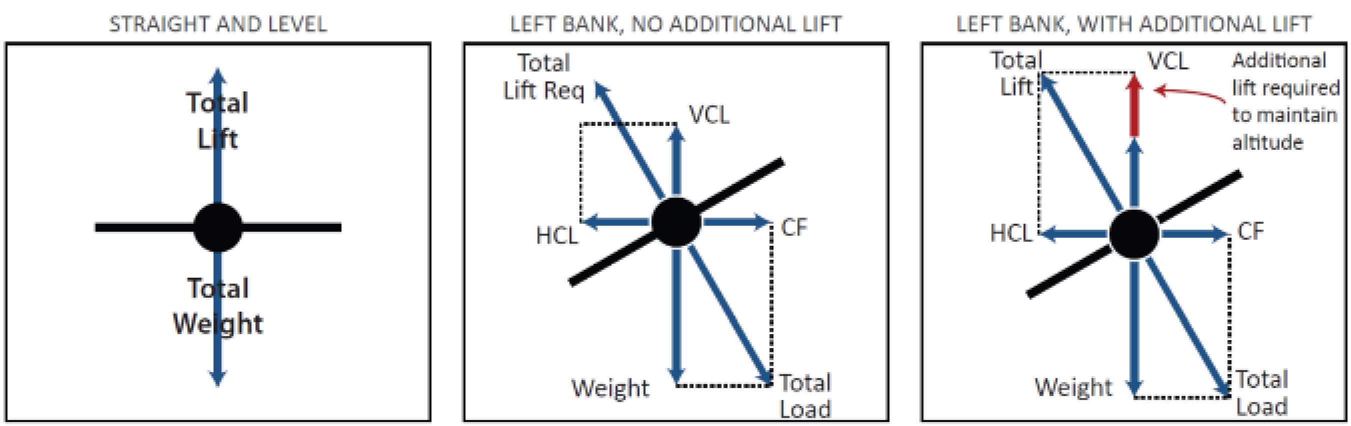
The steep turn maneuver consists of a constant altitude turn in either direction, using a bank angle between 45° to 60° (45° - Private, or 50° - Commercial). This will cause an overbanking tendency during which maximum turning performance is attained and relatively high load factors are imposed.

Why AI.IX.A.K1

Steep turns develop smoothness, coordination, orientation to outsides references, division of attention between control inputs and the constant need to scan for traffic, and control techniques necessary for the execution of maximum performance turns. The pilot also understands the effects of the over banking tendency and how to counteract it.

How:

1. **Maximum Performance Turn**
    A. An airplane's maximum turning performance is its fastest rate of turn and shortest radius of turn
        i. This changes with both airspeed and angle of bank
            a. The higher the airspeed, the bigger the radius
            b. The higher the bank angle, the smaller the radius
    B. In addition to other factors, the maximum bank angle is determined by the limiting load factor which can be maintained without stalling or exceeding the airplane's structural limitations
            a. In most small airplanes the max bank is approx. 50° to 60°
2. **The Science Behind It** AI.IX.A.K3
    A. What makes an airplane turn?
        i. As an aircraft banks lift is divided into a horizontal as well as a vertical component
            a. The horizontal component of lift pulls the aircraft through the turn
            b. The vertical component of lift must be increased to maintain altitude



B. Bank Angle, Load Factor and Stall Speed AI.IX.A.K3d
   i. Basics
      a. Load factor is the result of two forces: Centrifugal force & Weight
      b. As bank angle increases, the load factor increases and so does stall speed
         - Assuming level flight
         - The opposite also applies – decreasing bank angle decreases load factor and stall speed
   ii. Load Factors
      a. As bank increases beyond 45°, the loads on the aircraft increase rapidly
         - At a 60° bank, a load factor of 2 Gs are imposed on the aircraft structure
         - At a 70° bank, a load factor of approximately 3 Gs are placed on the aircraft
            a Most general aviation airplanes are stressed for approximately 3.8 Gs
      b. Regardless of the airspeed or type of aircraft involved, a given angle of bank in a turn, during which altitude is maintained, will always produce the same load factor
         - Ex: 60° of bank will always produce 2 Gs, irrespective of airspeed, aircraft, power setting, etc.
   iii. Stall Speed
      a. As we mentioned, increased bank leads to increased load factors, and increased load factor leads to an increased stall speed
         - The stall speed increases in proportion to the square root of the load factor
            a Ex: An aircraft will a normal stall speed of 50 knots in a 3G turn will stall near 85 knots
      b. Stalls encountered when the G-load, or load factor, exceeds 1G are called Accelerated Stalls
   iv. Thus, it's very important to recognize and understand the relationship between bank angle and stall speed, especially in a steep turn

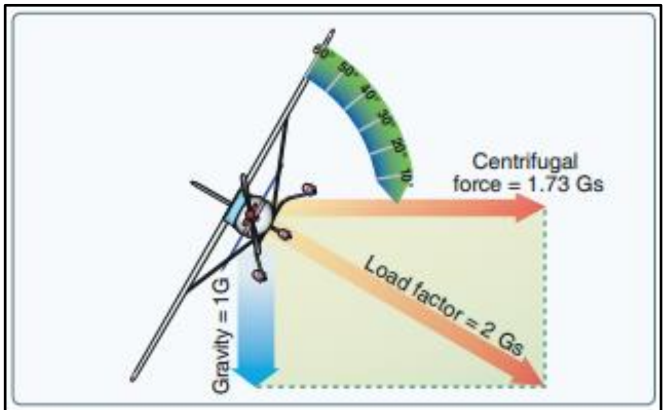
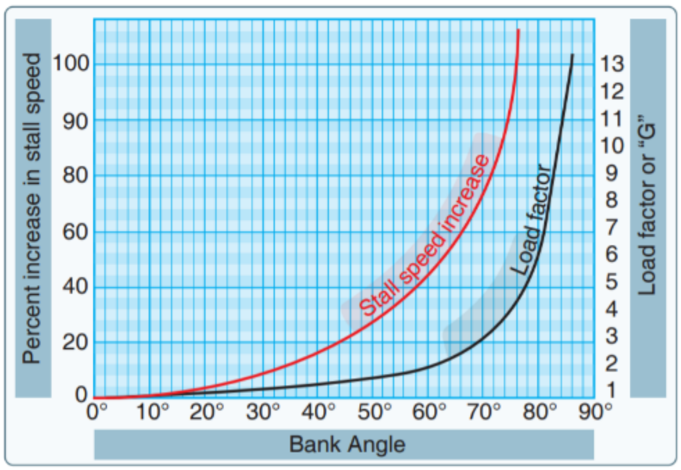


Figure 5-52. *Two forces cause load factor during turns.*



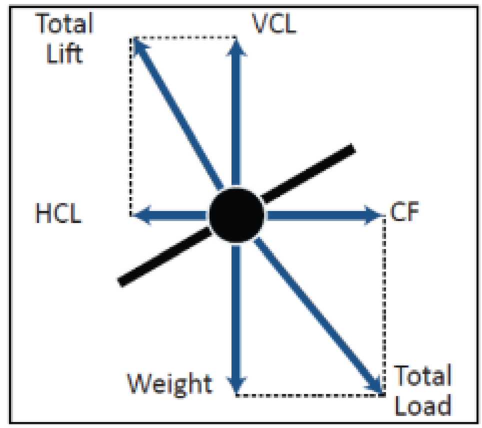
C. RM: Adverse Yaw (RM: Uncoordinated flight) AI.IX.A.R5
   i. In a turn, the downward deflected aileron (raised wing) produces more lift, and therefore more drag than the upward deflected aileron (lowered wing)
      a. This added drag yaws the airplane's nose in the direction of the raised wing (opposite the turn)
   ii. Rudder is used to counteract adverse yaw
      a. The slower the aircraft and the larger the aileron deflection, the more rudder required to maintain coordination
         - At slower speeds the rudder is less effective
         - Increased aileron deflection leads to increased lift on the raised wing which results in greater drag (adverse yaw)

D. RM: Torque Effect (left rolling tendency) (RM: Uncoordinated flight) AI.IX.A.K3a, AI.IX.A.R5

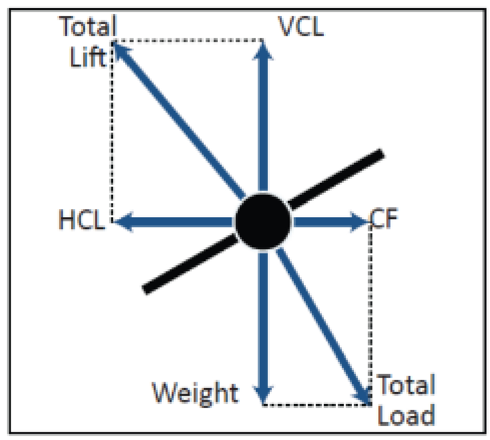
i. Newton's 3rd Law – every action has an equal and opposite reaction
   a. The internal engine parts and propeller are revolving in one direction (clockwise from the pilot's perspective), an equal force is trying to rotate the airplane in the opposite direction (counterclockwise, or left, from the pilot's perspective)
   b. This force acts around the longitudinal axis, tending to make the airplane roll to the left
      - The faster the engine/prop are spinning, the stronger the left turning tendency

ii. Torque Effect in Turns
   a. Torque is based on the speed the engine/propeller are rotating
      - The higher the power, the greater the turning tendency
         a Takeoff, for example, is when the turning tendency is most pronounced
   b. Most small aircraft combat the torque effect in cruise flight through trim tabs (whether adjusted in the flight deck by the pilot or via tabs mounted on the wings)
      - This is done to prevent having to hold right aileron pressure while cruising. Because of this, torque effect is generally negligible during a steep turn
         a Large changes in power would increase or decrease torque effect and require corresponding aileron adjustments

SKIDDING TURN



SLIPPING TURN



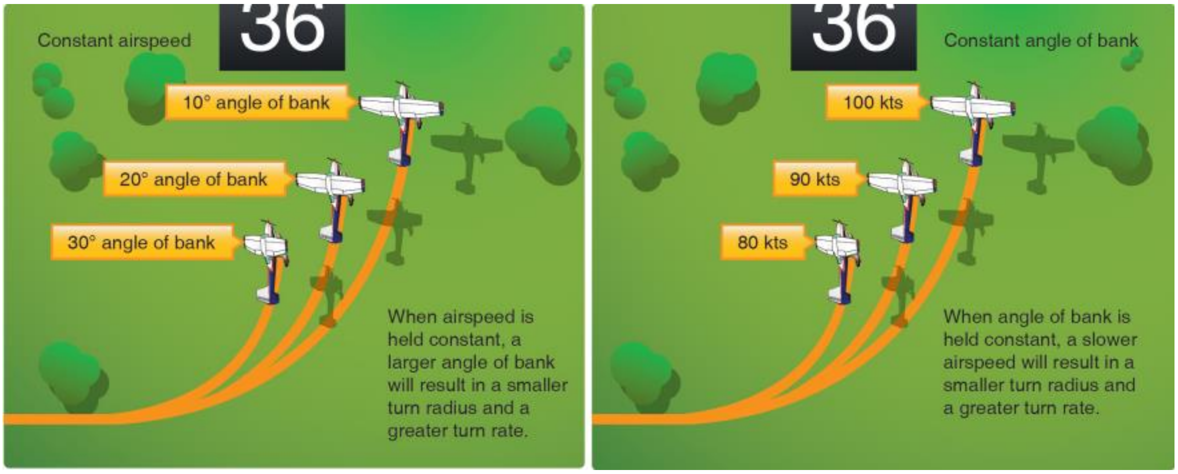
   c. Left Turn
      - Torque, as a left rolling tendency, encourages a left turn
         a Large power changes would require the pilot to adjust aileron input to maintain the desired bank angle
      - Torque combined with the other left turning tendencies can result in a skid in a left turn
         a Increase right rudder or reduce left rudder to counteract the skid
   d. Right Turn
      - Torque, as a left rolling tendency, discourages a right turn
         a Large power changes would require the pilot to adjust aileron input to maintain the desired bank angle
      - Torque combined with the other left turning tendencies can result in a slip in a right turn
         a Increase right rudder or decrease left rudder to counteract the slip

E. Rate & Radius of Turn AI.IX.A.K3e

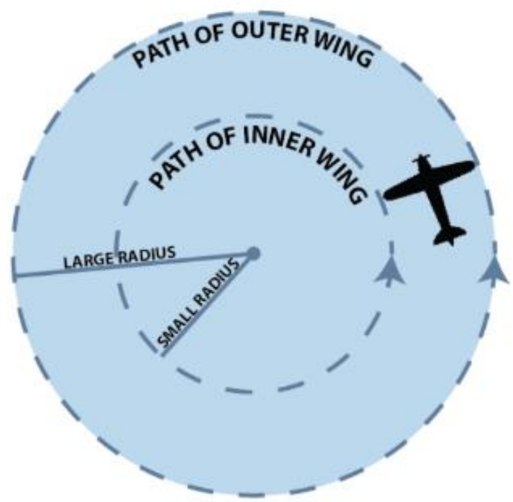
i. Rate
   a. Number of degrees per second the aircraft is turning
   b. Rate of turn is affected by both the bank angle and airspeed
      - As bank angle increases, so does the rate of turn
      - As airspeed increases, the rate of turn decreases
      - Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn

ii. Radius
   a. Describes the size of circle an aircraft would fly during a turn
      - The radius is a measurement taken from the center of the circle to any point on the circle
   b. Radius of turn is also affected by both the bank angle and airspeed (but opposite to Rate of Turn)
      - As bank angle increases, the radius of turn decreases

- As airspeed increases, the radius of turn increases
- Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn



F. Overbanking Tendency AI.IX.A.K3b
  i. During a turn, the wing on the outside travels a longer path relative to the wing on the inside of the turn
    a. As the radius of a turn becomes smaller, a significant difference develops between these two paths. Although the outside wing is traveling a farther distance (larger circle), both wings complete the circle in the same amount of time. Therefore, the outside wing is moving faster than the inside wing
      - The smaller the radius of the turn, the faster the outside wing is moving relative to the inside wing
      - Circumference of a Circle = 2πR (Pi * Radius)
        a The larger the radius, the larger the circumference or distance the wing travels
        b The outer wing of the turn will always have a larger radius and therefore travel a farther distance in the same amount of time



    b. Because the outside wing is traveling faster than the inside wing, it also develops more lift
      - Creates an overbanking tendency that is controlled with aileron in the opposite direction of the turn
      - Creates more drag on the outside wing resulting in a slight slip that must be corrected with rudder
  ii. Overbanking and Stability
    a. The overbanking tendency doesn't occur during every turn due to aircraft stability characteristics
      - Things such as dihedral, sweepback, keel effect, etc.
      - Although it varies, most general aviation aircraft exhibit some level of positive static stability
        a Positive static stability tries to return the aircraft to its original state, in this case zero bank/straight flight
        b The additional lift on the outside wing tries to roll the aircraft to a higher bank angle
    b. During a low bank turn, the aircraft's positive static stability outweighs the relatively small difference in speed between the outer and inner wings and the aircraft tends to return to wings level flight
      - Aileron must be held in the direction of the turn to maintain the bank
    c. During a medium banked turn, the aircraft's stability balances with the excess lift generated by the outside wing
      - Hypothetically, aileron could be removed, and the aircraft would maintain the bank angle

d. During a steep turn, the lift generated by the fast-moving outer wing is too great for the stability of the aircraft and the aircraft continues to roll into the turn
  - Aileron must be applied opposite the direction of the turn to maintain the bank angle

G. Maneuvering Speed (V_A) AI.IX.A.K3c
  i. The maximum speed at which the aircraft will stall prior to exceeding airframe limitations and potentially damaging the airframe (basically, you'll stall before you break)
    a. Above this airspeed full control deflection (or less than full depending on how fast you are going), can result in airframe stresses greater than what the aircraft is designed to handle
  ii. Weight Changes (Bold Method Video)
    a. V_A increases with increased weight and V_A decreases as weight is decreased
      - This means the aircraft can maneuver at higher airspeeds when heavy
    b. Example:
      - Imagine an aircraft straight-and-level at V_A and max gross weight (V_A is certified at max gross weight)
        a If the pilot were to pitch up excessively AOA increases, but right when you reach the limit load factor (3.8 Gs for a Normal rated aircraft) the aircraft will reach the critical AOA, stall, and return to 1G flight. Structural limitation of 3.8 Gs isn't exceeded, and the plane doesn't break
      - Now consider the same aircraft (still straight-and-level, still at V_A), but at a lighter weight
        a To maintain level flight, the aircraft now flies at a lower AOA. Because of this there is now a greater distance between the aircraft's AOA and the critical AOA. When the pilot pitches up excessively the aircraft will reach the limit load factor (3.8 Gs) prior to reaching the critical AOA, and the aircraft can break before it stalls
          1. For this reason, decreases in weight result in a lower maneuvering speed
    c. Since V_A is calculated at max gross weight and V_A decreases with weight, at lower weights the aircraft should be flown at slower speeds. To find out how much slower, you can use this formula:
      - $V_A\ (at \max gross\ weight) \times \sqrt{Actual\ Gross\ Weight\ \div Max\ Gross\ Weight}$
  iii. Perform all maneuvers, steep turns included, at or below V_A
    a. Keep in mind that the additional lift required to maintain altitude through the turn results in increased drag and therefore increased power is necessary to maintain airspeed through the turn
      - Keep the airspeed in your crosscheck
        a Too much speed can put the aircraft above V_A, and too little can put the aircraft close to a stall
      - When rolling out, reduce power to avoid accelerating as drag is reduced

3. Performing the Steep Turn AI.IX.A.K1, AI.IX.A.K2

A. Before Starting
  i. Pre-maneuver checklist
  ii. Select an altitude
    a. No lower than 1,500' AGL
    b. Select an altitude that is easy to read on the altimeter (500' increments are easiest)
  iii. RM: Clearing turns (RM: Collision Hazards) AI.IX.A.R2
    a. Especially important since the rate of turn will be rapid
    b. More collision hazard concepts below
  iv. Establish the recommended entry speed or a peed that does not exceed the design maneuvering speed (V_A)
  v. Ensure the aircraft is in straight and level flight, and trimmed
    a. Entering in a climb or descent will create extra work during the maneuver

B. Entering the Turn
  i. Note the entry heading/a visual reference to roll out on
  ii. Smoothly roll into the desired bank angle
    a. 45° (Private)

b. 50° (Commercial)
c. Apply rudder as necessary to maintain coordination
d. Establish opposite aileron as necessary to maintain the bank angle through the maneuver

iii. As the turn is established (around 30°), smoothly introduce back elevator pressure to increase the AOA
a. Considerable elevator force may be required
- Trim as necessary

b. Back pressure compensates for increasing load factor and reduced vertical component of lift

iv. Power must be added to maintain the entry altitude and airspeed
a. Additional elevator pressure increases the angle of attack. More lift equals more drag
b. Begin increasing power as required when passing approximately 30° of bank as well

v. RM: Coordination AI.IX.A.R5
a. Use rudder in conjunction with aileron to maintain coordination
- Adjust for adverse yaw & torque effect

b. Uncoordinated flight leads to changes in control inputs to maintain the turn
- Coordinated flight is more efficient, safer, and more predictable

c. A significant portion of yaw is experienced as motion away from or toward the earth's surface which may be confusing/disorienting initially
- Verify orientation with outside references and glances to the instruments

C. During the Turn

i. RM: Do not focus or stare at any one object (RM: Division of attention) AI.IX.A.R1
a. Awareness of the horizon relative to the nose/wings is necessary to maintain altitude & orientation
- Only watching the nose will result in difficulty holding altitude
- With practice, watching the nose and wings relative to the horizon can hold altitude within standards, and in time, considerably better

b. Loss of orientation
- Orientation is not just the bank/pitch attitude but where you are and what is around you
- Note the entry heading and find a visual reference to use
- Continue to scan for traffic
- Glance at the heading indicator and check visual references to know where you are in the turn
  a Heading moves quickly relative to normal turns; accelerate the scan of outside/inside references

ii. Adjustments
a. Increasing/decreasing altitude
- Relax or increase elevator pressure as appropriate
  a Make small changes to maintain/correct the altitude
  b Large changes can lead to fast altitude changes and a yo-yo/chasing effect
  c Power should be adjusted accordingly to maintain the entry airspeed
- Changes in bank angle may also be used to control altitude deviations
  a 1-3° of bank allows you to stay within bank tolerances and make a controlled altitude correction
  b Increasing bank decreases lift & decreasing bank increases lift
  c Again, large changes lead to large corrections and the yo-yo effect (chasing the altitude/bank)
- If the aircraft is descending and bank is excessive, reducing the bank angle may stop the descent
- If ascending and bank is shallow, increasing the bank angle may correct the altitude deviation
  a Make further corrections once bank has been fixed

b. Bank
- Adjust bank to maintain the required bank angle, pitch will likely need adjusted as well
  a Increasing bank decreases lift
    1. If bank is shallow, increase bank and add back pressure to maintain altitude

b Opposite applies for overbanking (decrease bank, reduce back pressure)

D. Roll Out
   i. General rule: Begin the rollout approximately ½ the bank angle from your entry heading (20º – 25º)
   ii. Time the rollout so the wings reach level flight when on the heading from which the maneuver was started
   iii. Gradually reduce back pressure and power as bank is decreased
   iv. If elevator was trimmed up, remove the trim during the rollout to prevent a large increase in altitude

4. Common Errors AI.IX.A.K4

A. Not clearing the area
B. Inadequate pitch control on entry or rollout
C. Gaining or losing altitude
D. Failure to maintain constant bank angle
E. Poor flight control coordination
F. Ineffective use of trim
G. Ineffective use of power
H. Inadequate airspeed control
I. Becoming disoriented
J. Performing by reference to the flight instruments rather than visual references
K. Failure to scan for other traffic during the maneuver
L. Attempting to start recovery prematurely
M. Failure to stop the turn on the designated heading

5. RM: Hazards (RM: Division of Attention, Distractions, SA & Disorientation, Task Prioritization) AI.IX.A.R1, AI.IX.A.R4

A. Dividing Attention
   i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
      a. Divide attention between flying, scanning, and communicating
   ii. Divide attention between control and the orientation of the aircraft
      a. Orientation does not just include the aircraft attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)
B. Distractions
   i. With the high task saturation associated with a steep turn, distractions can lead to excessive changes in altitude, loss of orientation, and an inability to clear for traffic
   ii. Focus on aircraft performance and clear for traffic
      a. If distracted, recognize the problem, admit it, stop the maneuver, and start over. Safety first.
C. Situational Awareness & Disorientation
   i. High turn rate & G forces make disorientation/loss of SA more common in steep turns than many maneuvers
   ii. Note entry heading/direction on the heading indicator/compass as well as by a visual outside reference
   iii. Using outside references, allows the pilot to manage the turn while maintaining awareness
   iv. If disoriented, stop the maneuver, admit the problem, and take action to regain SA/orientation
D. Task Prioritization
   i. A lot of things happen quickly during a steep turn, but safely flying the aircraft comes first
   ii. Establish a crosscheck and be very familiar with visual references to manage the tasks at hand
   iii. If you ever feel unsafe or too far behind, stop the maneuver, regain awareness, begin again when safe

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Low Altitude Maneuvering AI.IX.A.R3
B. IX. RM Concepts – Collision Hazards AI.IX.A.R2

Conclusion:
Brief review of the main points

In maintaining a properly coordinated steep turn, the pilot must use opposite aileron to maintain bank. Pitch should be controlled by adjusting elevator back pressure and bank angle. A smaller bank angle will result in more lift while an increased bank angle will reduce the lift. Maintaining coordination is very important and should be watched carefully throughout the maneuver.

Private Pilot ACS Skills Standards

1. Roll into a coordinated 360° steep turn with approximately a 45° bank.
2. Maintain the entry altitude ±100 feet, airspeed ±10 knots, bank ±5°, and roll out on the entry heading ±10°.

Commercial Pilot ACS Skills Standards

1. Roll into a coordinated 360° steep turn with approximately a 50° bank.
2. Perform the Task in the opposite direction.
3. Maintain the entry altitude ±100 feet, airspeed ±10 knots, bank ±5°; and roll out on the entry heading, ±10°.

IX.B. Steep Spirals

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should be able to perform the steep spiral maneuver to ACS standards, adjusting for varying wind speed and direction as well as changing bank angles.
Key Elements	1. Like Turns Around a Point 2. Increased Groundspeed = Increased Bank 3. Decreased Groundspeed = Decreased Bank 4. Keep the reference between the wing root and fuselage
Elements	1. Steep Spirals & Emergency Landings 2. Rules 3. Performing a Steep Spiral 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the elements involved in a properly flown steep spiral and can apply those elements to a well flown, coordinated steep spiral.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This can be a really cool maneuver, especially when combined with a power off 180º landing. The ability to maintain a position over the ground while descending (as in an emergency landing) makes for a much more confident pilot.

Overview

Review Objectives and Elements/Key ideas

What

A steep spiral is a constant gliding turn, during which a constant radius around a point on the ground is maintained - similar to turns around a point.

Why AI.IX.B.K1

The steep spiral improves pilot techniques for airspeed control, wind drift control, planning, orientation, and division of attention. The steep spiral is not only a valuable flight training maneuver, but it has practical application in providing a procedure for dissipating altitude while remaining over a selected spot in preparation for landing, especially for emergency forced landings.

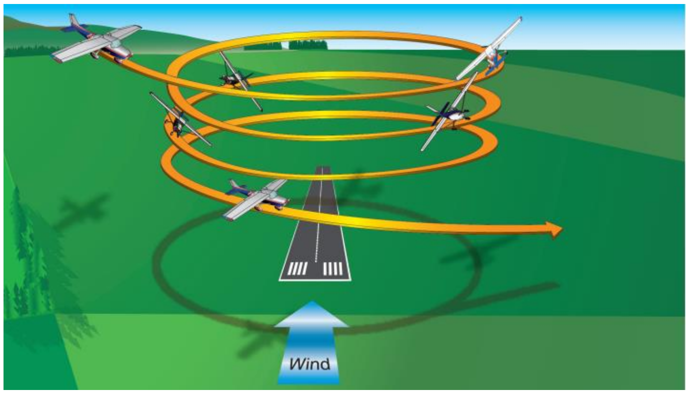
How:

1. **Steep Spirals & Emergency Landings** AI.IX.B.K2
   A. Trains the pilot to efficiently manage an engine failure and set themselves up for a successful, controlled landing
   B. In the case of an engine failure, proceed directly to an emergency landing airport/area
      i. Arriving with too much altitude, the pilot can apply the steep spiral to:
         a. Lose altitude while remaining directly over the landing zone
         b. Control and plan the descent to enter downwind at the most suitable altitude based on conditions
         c. Perform a controlled power-off 180 landing
2. **Rules** AI.IX.B.K3, AI.IX.B.K4
   A. Maintain an equal radius of turn around a point
      i. The radius should be such that the steepest bank will not exceed 60º
         a. Approximately ¼ mile is a good reference
      ii. Adjust for changing tailwinds/headwinds
         a. Like turns around a point
   B. To maintain a consistent radius, bank angle is increased as groundspeed increases and decreased as groundspeed decreases
   C. Enter on the downwind
      i. This will establish the steepest bank initially since groundspeed is the highest at this point
         a. RM: If the pilot entered on the upwind (slowest groundspeed) and rolled into 45º of bank, upon reaching the downwind leg (highest groundspeed) bank would have to be increased to excessively
   D. The spiral should be continued through three 360º spirals
      i. Sufficient altitude must be attained
         a. Do not continue below 1,500’ AGL unless performing an emergency landing in conjunction
         b. Triple the approximate altitude lost per turn in your aircraft and add 1500’ to plan a min entry altitude
            - Minimum altitude = 1500’ AGL + 3 turns
   E. Clear the engine periodically while headed into the wind

i. Operating at idle for a prolonged period of time may result in excessive engine cooling or spark plug fouling
ii. Clearing while facing into the wind minimizes any variation in groundspeed and radius of turn

F. Limitations
i. RM: Stay within all published aircraft limitations AI.IX.B.R7
ii. Reference the POH for applicable airspeed & airframe limitations (bank angle)

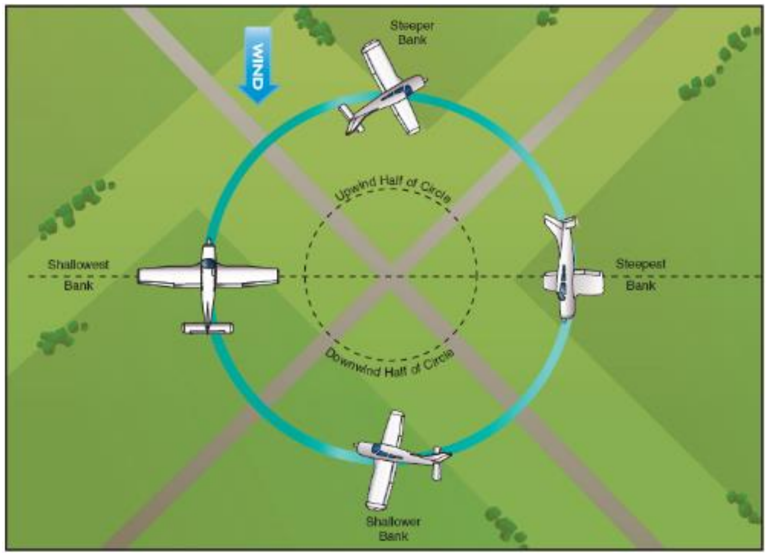
3. Performing a Steep Spiral AI.IX.B.K1, AI.IX.B.K3, AI.IX.B.K4



A. Before Starting
i. *Pre-maneuver checklist
a. Fuel Pump ON
b. Mixture RICH
c. Lights ON
d. Gauges GREEN
ii. Ensure the area is clear of traffic
a. Below, at, and above your altitude
iii. Sufficient altitude must be obtained so that the spiral may last through at least three 360° turns
iv. Select a ground reference point
a. Small reference point - Ex: House, Silo, Chimney, Chicken House, etc.
b. Should be in a sparsely populated area with surrounding area that would permit an emergency landing
v. Set up to enter the maneuver on the downwind
a. This will establish the steepest bank initially – Highest groundspeed
vi. Position the aircraft so it will pass within ¼ mile of the point on the downwind side
a. Visually approach the point to put it directly below your left foot

B. Entering the Spiral
i. Close the throttle and establish the recommended entry airspeed
a. Trim for this speed
b. *DA20: 83 knots
ii. A gliding spiral should be started, and a turn of constant radius maintained around the reference point
a. When over the point, the aircraft will block the pilot's view of the point
- Technique: Once the point disappears, wait a few seconds, and start the turn past the reference point, establishing the ¼ radius
  - a Starting the turn early (even if ¼ mile to the side) can result in turning directly over the point
b. *Upon rolling in, put the reference point between the wing root and the fuselage
- Initial bank on the downwind leg will establish the steepest bank for the maneuver
  - a 45° is a good starting point
- This is for a low wing aircraft and worked great in the DA20. Adjust as required

C. During the Spiral
i. *Keep the reference point between the fuselage and the wing root to visually maintain the correct radius
ii. Judge wind direction/speed during descent and adjust bank to maintain a uniform radius
a. As the aircraft descends vertically, wind direction may change
- The pilot must constantly adjust control inputs for the changing wind conditions
iii. RM: Wind Correction (RM: Effects of wind) AI.IX.B.R6
a. Entering with a tailwind (downwind) requires increased bank to maintain a constant radius
- The faster the groundspeed, the steeper the bank
- It is important to enter on the downwind to establish the steepest bank initially
b. Tracking into a headwind, bank must be decreased



- The slower the groundspeed, the shallower the bank
c. Think turn radius; higher speed = greater radius and vice versa
  - Increase bank as groundspeed increases and decrease bank as groundspeed decreases

iv. The pilot also must adjust pitch to maintain a stabilized descent speed
  a. *DA20: 83 knots
  b. In contrast to turns around a point, the pilot must vary pitch to maintain a constant airspeed throughout the entire maneuver
  c. Failure to hold airspeed constant will cause the turn radius and bank to vary
  d. If airspeed is too fast, pitch up to slow
  e. If airspeed is too slow, pitch down to speed up
  f. Be aware that a large change in speed may require a change in bank to maintain a constant radius

v. RM: Uncoordinated use of flight controls AI.IX.B.R5
  a. Maintain coordination for a more stable, smoother spiral
    - Uncoordinated flight results in additional drag on the aircraft
      a When coordinated again, airspeed will likely increase, resulting in a change in descent rate
    - Failure to hold a constant airspeed varies turn radius and the required bank angle
  b. Do not use rudder to increase or decrease the rate of turn to adjust the ground track
    - Can lead to a cross-control situation – especially hazardous at low speeds and altitudes

vi. Divide attention between the ground reference point and instruments
  a. Check the amount of altitude being lost during each turn
    - This establishes the last 360 and entry to the pattern ‘downwind’ for an emergency landing

D. Rolling out of the Turn
  i. After completing three complete rotations, roll out within 10° of the entry heading
    a. Technique: Count the turns out loud and bug the entry heading
  ii. During the rollout, smoothness is essential, and the use of controls must be so coordinated that no increase or decrease of airspeed results when the straight glide is resumed

4. Common Errors AI.IX.B.K5

A. Not clearing the area
B. Inadequate pitch control on entry or rollout
C. Not correcting the bank angle to compensate for wind
D. Poor flight control coordination
E. Ineffective use of trim
F. Inadequate airspeed control
G. Becoming disoriented
H. Performing by reference to the flight instruments rather than visual references
I. Not scanning for other traffic during the maneuver
J. Not completing the turn on the designated heading or reference

5. RM: Hazards

A. Dividing Attention AI.IX.B.R1

i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
    a. Over concentration on the reference point or the instruments results in the other being neglected and a poorly performed maneuver
    b. Crosscheck should be based on outside references and supplemented with inside instrument indications
        - Allows the pilot to divide attention between control and orientation of the aircraft
        - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)

ii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety comes first

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

B. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.B.R4
C. IX. RM Concepts – Low Altitude Maneuvering AI.IX.B.R3
D. IX. RM Concepts – Collision Hazards AI.IX.B.R2

Conclusion:
Brief review of the main points
The steep spiral is just like a turn around a point with the addition of a constant speed descent. The same procedures apply with the addition of making adjustments to the pitch attitude to maintain 83 knots. It is important to stay oriented in relation to the number of turns you have made and the entry and rollout heading as it is easy to get confused.

Commercial Pilot ACS Skills Standards
1. Apply wind drift correction to track a constant radius circle around selected reference point with bank not to exceed 60° at steepest point in turn.
2. Maintain the specified airspeed, ±10 knots, and roll out toward an object or specified heading, ±10° and complete the maneuver no lower than 1,500’ AGL.

IX.C. Chandelles

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner can complete a Chandelle as prescribed in the ACS.
Key Elements	1. Maximum Performance 2. 1st 90º - Constant Bank, Changing Pitch 3. 2nd 90º - Constant Pitch, Changing Bank 4. Coordination
Elements	1. Aerodynamics Recap 2. Maximum Performance 3. Performing the Chandelle 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner performs a smooth, well-coordinated chandelle without the instructor's guidance. The learner also understands the factors influencing control and coordination throughout the maneuver.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The Chandelle is a *Maximum Performance* climbing 180° turn. We're going to get the airplane to climb as much as we possibly can, going from V_A down to just above the stalling speed.

Overview

Review Objectives and Elements/Key ideas

What

A maximum performance climbing turn beginning from approximately straight and level flight and ending at the completion of a precise 180° turn in a wings level, nose high attitude at the minimum controllable airspeed. The airplane should gain the most altitude possible for a given degree of bank and power setting without stalling.

Why AI.IX.C.K1

This maneuver greatly develops the pilot's coordination, orientation, planning, and accuracy of control during maximum performance flight. In real-life scenarios, it provides the pilot with the ability to make a maximum performance climbing turn which can be useful in confined areas.

How:

1. **Aerodynamics Recap** AI.IX.C.K2
   A. Maneuvering Speed (V_A) AI.IX.C.K2c
      i. The maximum speed at which the aircraft will stall prior to exceeding airframe limitations and potentially damaging the airframe (basically, you'll stall before you break)
         a. Above this airspeed full control deflection (or less than full depending on how fast you are going), can result in airframe stresses greater than what the aircraft is designed to handle
      ii. Weight Changes (Bold Method Video)
         a. V_A increases with increased weight and V_A decreases as weight is decreased
            - This means the aircraft can maneuver at higher airspeeds when heavy
         b. Example:
            - Imagine an aircraft flying straight-and-level at V_A and at max gross weight (V_A is certified at max gross weight)
               a If the pilot were to pitch up excessively AOA increases, but right when you reach the limit load factor (3.8 Gs for a Normal rated aircraft) the aircraft will reach the critical AOA, stall, and return to 1G flight. Structural limitation of 3.8 Gs isn't exceeded, and the plane doesn't break
            - Now consider the same aircraft (still straight-and-level, still at V_A), but at a lighter weight
               a To maintain level flight, the aircraft now flies at a lower AOA. Because of this there is now a greater distance between the aircraft's AOA and the critical AOA. When the pilot pitches up excessively the aircraft will reach the limit load factor (3.8 Gs) prior to reaching the critical AOA, and the aircraft can break before it stalls
                  1. For this reason, decreases in weight result in a lower maneuvering speed
         c. Since V_A is calculated at max gross weight and VA decreases with weight, at lower weights the aircraft should be flown at slower speeds. To find out how much slower, you can use this formula:
            - $V_A\ (at \max gross\ weight) \times \sqrt{Actual\ Gross\ Weight\ \div Max\ Gross\ Weight}$
      iii. Perform all maneuvers at or below V_A

a. Keep in mind that the additional lift required to maintain altitude through the turn results in increased drag and therefore increased power is necessary to maintain airspeed through the turn
  - Keep the airspeed in your crosscheck
    - a Too much speed can put the aircraft above V_A, and too little can put the aircraft close to a stall
  - When rolling out, reduce power to avoid accelerating as drag is reduced

B. Bank Angle, Load Factor and Stall Speed AI.IX.C.K2d

i. Basics

a. Load factor is the result of two forces: Centrifugal force & Weight (pictured, below)

b. As bank angle increases, the load factor increases and so does stall speed
  - Assuming level flight
  - The opposite also applies – decreasing bank angle decreases load factor and stall speed

ii. Load Factors

a. As bank increases beyond 45°, the loads on the aircraft increase rapidly
  - At a 60° bank, a load factor of 2 Gs are imposed on the aircraft structure
  - At a 70° bank, a load factor of approximately 3 Gs are placed on the aircraft
    - a Most general aviation airplanes are stressed for approximately 3.8 Gs

b. Regardless of the airspeed or type of aircraft involved, a given angle of bank in a turn, during which altitude is maintained, will always produce the same load factor
  - Ex: 60° of bank will always produce 2 Gs, irrespective of speed, aircraft, power, etc.

iii. Stall Speed

a. As we mentioned, increased bank leads to increased load factors, and increased load factor leads to an increased stall speed
  - The stall speed increases in proportion to the square root of the load factor
    - a Ex: An aircraft will a normal stall speed of 50 knots in a 3G turn will stall near 85 knots

b. Stalls encountered when the G-load, or load factor, exceeds 1G are called Accelerated Stalls

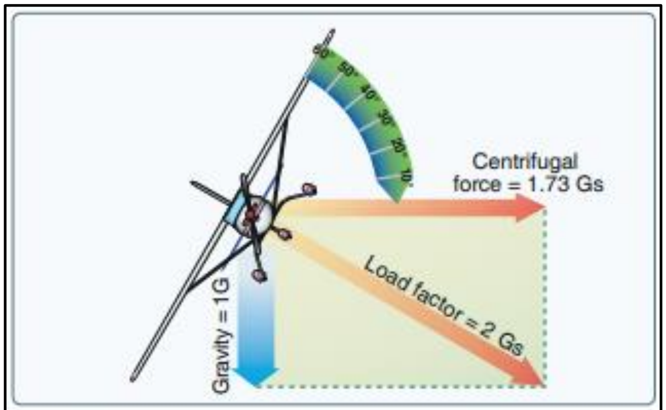
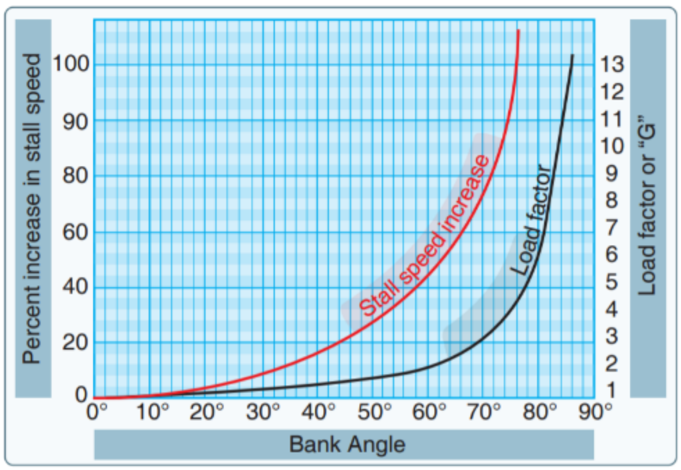


Figure 5-52. *Two forces cause load factor during turns.*



iv. Chandelles & Accelerated Stalls

a. The airplane will stall at a higher indicated airspeed when excessive maneuvering loads are imposed

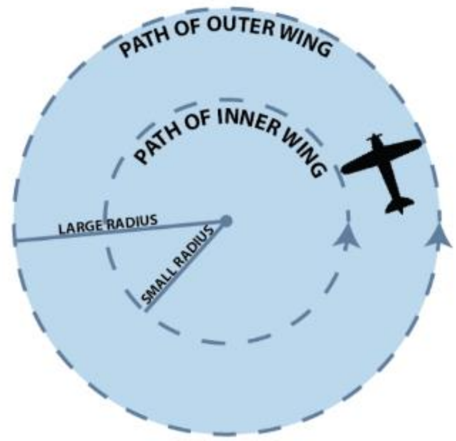
b. Smoothly and positively apply the control pressures to execute the chandelle
  - Abrupt, aggressive control inputs could lead to an accelerated stall

C. Overbanking Tendency AI.IX.C.K2b

i. During a turn, the wing on the outside travels a longer path relative to the wing on the inside of the turn

a. As the radius of a turn becomes smaller, a significant difference develops between these two paths.
  - The smaller the radius of the turn, the faster the outside wing is moving relative to the inside wing

b. Because the outside wing is traveling faster than the inside wing, it also develops more lift



- Creates an overbanking tendency that is controlled with aileron in the opposite direction of the turn
- Creates more drag on the outside wing resulting in a slight slip that must be corrected with rudder

ii. Overbanking and Stability
  a. Overbanking doesn't occur during every turn due to the aircraft's inherent stability characteristics
    - Although it varies, most GA aircraft exhibit some level of positive static stability
      a Positive static stability tries to return the aircraft to its original state, in this case zero bank/straight flight
      b The additional lift on the outside wing tries to roll the aircraft to a higher bank angle
  b. Low Bank: Positive static stability outweighs the relatively small difference in speed between the outer and inner wings and the aircraft tends to return to wings level flight
    - Aileron must be held in the direction of the turn to maintain the bank
  c. Medium Bank: Positive static stability balances with the excess lift generated by the outside wing
    - Hypothetically, aileron could be removed, and the aircraft would maintain the bank angle
  d. Steep Bank: Lift generated by the fast-moving outer wing is too great for aircraft stability and the plane continues to roll
    - Aileron must be applied opposite the direction of the turn to maintain the bank angle

iii. Overbanking Tendency and the Chandelle
  a. When in a nose high turning attitude at a slow airspeed, as at the top of a Chandelle, bank will increase
  b. Use opposite aileron to maintain desired bank angle and prevent overbanking

D. RM: Turn Rate & Radius AI.IX.C.R7
  i. Rate of Turn
    a. Number of degrees per second the aircraft is turning
    b. Affected by both the bank angle and airspeed
      - As bank angle increases, so does the rate of turn
      - As airspeed increases, rate of turn decreases
      - Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn
  ii. Radius of Turn
    a. Describes the size of circle an aircraft would fly during a turn
      - The radius is a measurement taken from the center of the circle to any point on the circle
    b. Affected by both the bank angle and airspeed (but opposite to Rate of Turn)
      - As bank angle increases, the radius of turn decreases
      - As airspeed increases, the radius of turn increases
      - Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn
  iii. Confined Area Operations
    a. Minimizing radius and maximizing turn rate provides the most confined area for a turn
      - Higher bank and slower airspeed

2. Maximum Performance

A. The plane should gain the most altitude possible for a degree of bank and power setting without stalling
  i. However, since numerous atmospheric variables beyond your control will affect the amount of altitude gained, the altitude gained is not a criterion on the quality of the chandelle

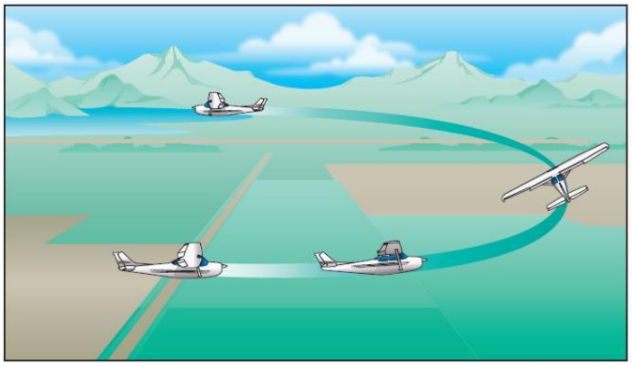
B. RM: Energy Management AI.IX.C.R6
  i. If pitch is increased too little or too slowly, climb performance is limited

   ii. If pitch is increased too high, or too quickly, the aircraft will stall before completion
   iii. Balance in energy to maximize performance

3. Performing the Chandelle AI.IX.C.K1, AI.IX.C.K3, AI.IX.C.K4

A. Before Starting
   i. Selecting an altitude
      a. No lower than 1,500’ AGL
      b. Select an easy-to-read altitude on the altimeter
         - Nearest 500’ increment
   ii. *Pre-maneuver checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
   iii. Ensure the area is clear of traffic
      a. Below, as well as at, and above your altitude
         - Above is important (climbing maneuver)
   iv. Configure per the POH
      a. Generally, flaps and gear should be in the UP position
   v. The airplane should be in straight and level flight
      a. *At 95 knots (Not above V_A): 2200 – 2300 RPM
      b. Note heading (rollout will be on the reciprocal) – Bug it if necessary
   vi. Choose a visual reference point 90° off the wing in the direction the turn will be in

B. First 90° of the Turn – Constant bank, Changing pitch
   i. Smoothly enter a coordinated 30° turn
      a. Normally, this will not exceed approximately 30° of bank
      b. Once the bank is established, the angle of bank should remain constant until the 90° point
         - Monitor the bank angle as it may begin to increase. Adjust as necessary
         - Remember, as airspeed decreases, rate of turn increases
            a Overbanking tendency can become a factor. Adjust aileron to maintain 30° bank angle
   ii. After the bank is established, apply maximum power, and initiate a climbing turn
      a. No other power adjustments are made during this maneuver
      b. Smoothly apply back-elevator pressure to increase the pitch attitude at a constant rate to attain the highest pitch attitude as 90° of the turn is completed
         - *Pitch attitude will be approximately 12° (adjust for specific aircraft) AI.IX.C.K4
            a 15° tends to get to the stall speed too early, while 10° doesn’t quite reach it
   iii. Considerations
      a. If the pitch is increased too quickly the aircraft will stall before reaching 180°
      b. If the pitch is increased too slowly, the aircraft will not come close to the stall speed
   iv. RM: Maintain Coordination (RM: Uncoordinated flight) AI.IX.C.K2a, AI.IX.C.R5
      a. As the airspeed decreases through the turn, the torque effect becomes more pronounced
         - The slower the aircraft, the less effective the flight controls
         - Right rudder pressure should be gradually increased to control yaw and keep coordinated
      b. In a left turn, less right rudder will be necessary to compensate than in a right turn



   v. At the 90° mark, airspeed should be approximately at the midpoint between the entry airspeed and the minimum controllable airspeed of the airplane
   vi. Summary of the 1st 90° of the turn - Constant bank, increasing pitch
      a. Bank is held constant
      b. *Pitch is increased at a constant rate to attain

the highest pitch attitude (12°) at the 90° point
c. Increase right rudder to keep the airplane coordinated

C. 2nd 90° of the Turn – Constant pitch, Changing bank
   i. *Reaching 90°, begin rolling out the bank at a constant rate while maintaining constant pitch (12°)
      a. Roll out approximately 10° of bank for every 30° of heading change
   ii. As airspeed decreases increased back pressure will be required to maintain a constant pitch attitude
      a. As airspeed approaches stall, maintain back pressure to obtain maximum performance without stalling
   iii. Left turning tendencies become more prevalent – use right rudder to coordinate turns in both directions
   iv. Summary of the 2nd 90° of the turn - Constant pitch, decreasing bank
      a. *Back pressure is adjusted to maintain pitch (12° high)
      b. Bank is decreased at a constant rate to roll wings level at the 180° point
      c. Increase rudder pressure as necessary as the airspeed slows
D. The Rollout
   i. Time the rollout so that wings are level at the 180° point
   ii. The pitch attitude should be held momentarily while the airplane is at its minimum controllable airspeed
   iii. RM: Left Chandelle Rollout (RM: Uncoordinated flight) AI.IX.C.R5
      a. The left wing must be raised by lowering the left aileron
         - This creates more drag, resulting in a tendency for the airplane to yaw to the left
         - With the low air airspeed, torque effect/p-factor also tries to make the airplane yaw left
            a Thus, there are two forces pulling the nose to the left
               1. To maintain coordination, considerable right rudder pressure is required during the rollout
   iv. RM: Right Chandelle Rollout (RM: Uncoordinated flight) AI.IX.C.R5
         - The right wing must be raised by lowering the right aileron
            a This creates more drag on the right wing and tends to make the airplane yaw right
         - At the same time, the effect of torque/p-factor at the lower airspeed causes the nose to yaw left
         - Thus, aileron drag pulling the nose right and torque pulling left work against each other
            a Less right rudder is needed
      b. This rollout is accomplished mainly by applying aileron pressure
         - Right rudder should be gradually released, and left rudder applied if necessary
   v. In either rollout, when the wings are level, aileron drag is neutralized, and torque/p-factor is acting alone
E. Finishing the maneuver
   i. Gradually reduce pitch to return to level flight, allowing the plane to accelerate while maintaining altitude
      a. Increase right rudder during as pitch decreases to counter the turning tendencies caused by gyroscopic precession of the propeller
      b. Adjust pitch, power, and trim for cruise flight
F. Factors related to failure in achieving maximum performance
   i. Maximum performance is degraded if pitch (and therefore airspeed) is not established correctly
      a. If pitch is too high, the plane stalls before reaching max performance, too low and the climb is degraded
   ii. Maximum performance is degraded if bank is not established correctly
      a. A constant 30° bank is essential; too much bank results in an early completion of the turn and less altitude gained, whereas too little results in slowing excessively, or stalling, prior to completing the turn
   iii. Maximum performance is degraded if power is not set to max
      a. Less power results in less altitude, ensure maximum power is used
   iv. Maximum performance is degraded if the aircraft is not coordinated throughout the maneuver
      a. Uncoordinated flight results in extra drag, decreasing performance
G. RM: Dividing Attention AI.IX.C.R1
   i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.

a. Over concentration inside or outside will result in the other being neglected and a poor maneuver
b. Allows the pilot to divide attention between aircraft control and the orientation
    - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)

ii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety comes first

4. Common Errors AI.IX.C.K5

A. Not clearing the area
B. Initial bank is too shallow resulting in a stall
C. Initial bank is too steep resulting in failure to gain maximum performance
D. Allowing the bank angle to increase after initial establishment
E. Not starting the recovery at the 90° point in the turn
F. Allowing the pitch attitude to increase as the bank is rolled out during the second 90° of turn
G. Leveling the wings prior to the 180° point being reached
H. Pitch attitude is low on recovery resulting in airspeed well above stall speed
I. Application of flight control pressures is not smooth
J. Poor flight control coordination
K. Stalling at any point during the maneuver
L. Execution of a steep turn instead of a climbing maneuver
M. Not scanning for other traffic during the maneuver
N. Performing by reference to the instruments rather than visual references

5. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.C.R4
B. IX. RM Concepts – Low Altitude Maneuvering AI.IX.C.R3
C. IX. RM Concepts – Collision Hazards AI.IX.C.R2

Conclusion:

Brief review of the main points

The chandelle is a maximum performance climbing 180° turn. During the first half of the turn, bank constant while pitch is consistently increased. Through the second half of the turn, pitch is held constant, and bank is consistently decreased. Throughout the maneuver it is important to maintain coordinated, especially as the speed of the airplane decreases.

Commercial Pilot ACS Skills Standards

1. Select an altitude that will allow the maneuver to be performed no lower than 1,500’ (AGL).
2. Establish the angle of bank at approximately 30°.
3. Complete rollout at the 180° point, ±10°, just above stall speed, maintaining that speed momentarily avoiding a stall.

IX.D. Lazy Eights

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner understands the elements and control inputs necessary to perform the lazy eight maneuver. The learner shows the ability to perform a coordinated, well planned, and oriented lazy eight as prescribed in the ACS.
Key Elements	1. Transfer of Energy 2. Constantly changing control pressures 3. Symmetry
Elements	1. Relating the Maneuver 2. Performing the Lazy Eight 3. Energy Management 4. Rudder Control 5. Overbanking Tendency 6. Summary 7. Common Errors 8. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the elements involved in performing a lazy eight and can perform the lazy eight on their own.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Who wants to be a crop duster when they grow up? This is the maneuver you have to know if you want to crop dust. And, although challenging, it's a pretty fun maneuver.

Overview

Review Objectives and Elements/Key ideas

What

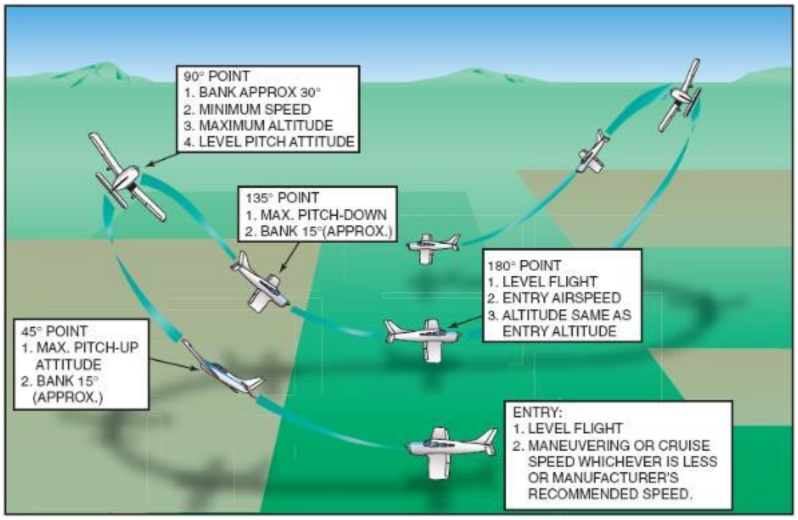
A maneuver consisting of two 180° turns in opposite directions, while making a climb and descent in a symmetrical pattern during each of the turns. It is designed to develop proper coordination of controls through a wide range of airspeeds and attitudes so that certain accuracy points are reached with planned attitude and airspeed. It is the only standard flight training maneuver during which at no time do the forces on the controls remain constant.

Why AI.IX.D.K1

The lazy eight develops proper coordination of the controls through a wide range of airspeeds and attitudes. It is a great trainer because of the constantly varying forces and attitudes required. It also helps develop subconscious feel, planning, orientation, coordination, and speed sense.

How:

1. **Relating the Maneuver**
   A. The maneuver can be compared to a half pipe and a transfer of energy
      i. A transfer of energy as we climb the half pipe and then descend on the other side
         a. The energy is used to get to the top
            - Constant power setting
         b. Then we ride the 'pipe' back down
   B. Crop-dusting maneuver
2. **Performing the Lazy Eight** AI.IX.D.K1, AI.IX.D.K3, AI.IX.D.K4
   A. Before Starting
      i. Select an altitude
         a. No lower than 1,500' AGL
         b. Select an altitude that is easy to read on the altimeter
            - 500' increment
      ii. Pre-maneuver checklist
      iii. Ensure the area is clear of traffic
         a. Below, at, and above your altitude
      iv. Straight and level flight at cruise power, at or below V_A
         a. Reference any other performance & airspeed limitations
      v. Choose visual reference points at 45°, 90°, & 135° in the direction of the turn
         a. Should be easy to identify



        b. Don't use points that are too close to your position, ensure that they are toward or on the horizon
B. Starting the Lazy Eight
    i. Started from straight-and-level flight with a *gradual* climbing turn in the direction of the 45° reference point
        a. *VERY gently begin a climb and turn to each reach 15° of pitch (max pitch) & bank at the 45° point
            - Pitch must be increased faster than bank
                a As pitch is increased airspeed decreases and therefore the rate of turn increases
                    1. Since the bank is also being increased, the rate of turn is further increasing
                    2. Unless the maneuver is started with a very slow rate of roll, the combination of increased pitch and increasing bank will cause the rate of turn to be so rapid the 45° point will be reached before the highest pitch attitude
                    3. Decreasing airspeed also means increased torque
                        a. Right rudder will be necessary to maintain coordination
C. At the 45° point
    i. *The pitch attitude should be at maximum (15°)
    ii. The angle of bank should be at 15° and continue to increase at the same rate
    iii. The pitch attitude should start to decrease slowly toward the horizon and the 90° reference point
        a. Since speed is still decreasing, right rudder pressure is required to counteract the left turning tendencies
            - As the airspeed slows, the rudder becomes less effective
D. 45° to 90°
    i. The angle of bank continues to increase to reach 30° of bank at the 90° point of the turn
        a. Bank continues to increase at the same rate as the first 45° of turn
        b. No more than 30° of bank
    ii. Pitch continues to decrease to pass through level flight at the 90° point
        a. Decrease at the same rate as the increase in the initial climbing turn
        b. As the aircraft continues to slow, additional right rudder pressure will be necessary
E. At the 90° point
    i. The bank should be at the maximum angle (approximately 30°)
        a. Opposite aileron may be required to maintain the bank angle
            - This may result in a crossed control situation
                a This is OK, as long as the airplane remains coordinated
    ii. The airspeed should be at its minimum (5 to 10 knots above the stall speed)
        a. Therefore, the rudder pressure required will be the highest
    iii. The pitch attitude should be passing through level flight
        a. Pass through the 90° reference point and the horizon simultaneously
    iv. The airplane should be flown into a descending turn
        a. The nose should describe the same size loop below the horizon as it did above
    v. When passing through the 90° point, bank should be gradually decreased, the nose allowed to lower
        a. Guide the nose down, don't dive
F. 90° to 135°
    i. Bank is consistently decreased to reach 15° of bank at the 135° of turn point
        a. Opposite of the beginning of the maneuver
    ii. Pitch is decreased to reach the maximum pitch down at 135°
        a. *Max Pitch down is approximately 5°-7°
            - Less than max pitch up since we now have gravity, thrust, and a forward component of lift working together to descend the aircraft
                a Going up we only have thrust; therefore, we pitch up more aggressively than we pitch down
                    1. Lift has a rearward component when climbing
    iii. Airspeed will begin increasing during this descending turn

a. It will be necessary to gradually relax rudder and aileron pressure

G. At the 135° point
   i. *The nose of the airplane should be at its lowest pitch attitude (5° - 7°)
   ii. Bank should be at 15°
   iii. The airspeed will be increasing so it will be necessary to gradually relax rudder and aileron pressure
H. 135° to 180°
   i. Continue to decrease bank to level the wings
      a. Note the amount of turn remaining and adjust the rate of rollout and pitch change so that the wings become level and the original airspeed is attained in level flight just as the 180° point is reached
      b. The airspeed will continue to increase so it will be necessary to further relax rudder and aileron pressure
   ii. Continue to increase pitch to bring the nose back to the horizon
      a. Altitude should be where the maneuver was started
      b. Why everything needs to come back to the same place:
         - When crop dusting,
            a Come in too high, then wind and other variables will scatter your 'dust'
            b Come in too low, you could hit the ground
            c Come in off heading, then you're going to miss spots/re-cover spots
         - It's going to make a mess
I. At the 180° point
   i. At the starting altitude & 180° point, start a climbing immediately in the opposite direction
   ii. Using the same visual references, the second turn should mimic the first as closely as possible
J. RM: Dividing Attention AI.IX.D.R1
   i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
      a. Over concentration inside or outside will result in the other being neglected and a poor maneuver
      b. Allows the pilot to divide attention between aircraft control and the orientation
         - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)
   ii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety first

3. RM: **Energy Management** AI.IX.D.R6

A. Unsymmetrical Eights
   i. A lazy eight should consist of two symmetrical 180-degree turns, in opposite directions
   ii. A failure to manage energy leads to unsymmetrical turns. Differences between the two turns can include:
      a. Differing pitch attitudes
      b. Differing bank angles
      c. Differing rate of pitch and/or bank
      d. Uncoordinated flight
B. Altitude Changes
   i. The correct power setting is that which will maintain the altitude for the maximum and minimum airspeeds used during the climbs and descents of the eight
      a. If excess power is used, the aircraft will have gained altitude at the end of the maneuver
      b. If insufficient power is used, the aircraft will have lost altitude

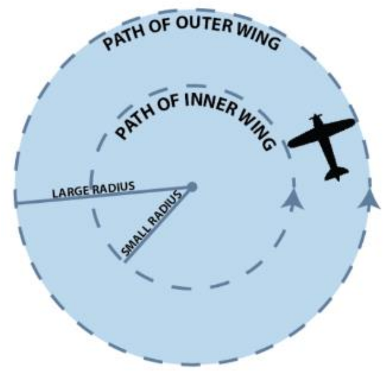
4. RM: **Rudder Control** (RM: Uncoordinated flight) AI.IX.D.K2, AI.IX.D.R5

A. Due to the decreasing airspeed, considerable right rudder pressure is gradually applied to counteract the left turning tendencies, such as torque and p-factor, at the top of the eight in both the right and left turns
   i. The pressure will be greatest at the point of lowest airspeed
B. More right rudder pressure will be needed during the climbing right turn
   i. Right Turn: Rudder compensates for Left Turning Tendencies plus Adverse Yaw
      a. Sufficient/coordinated right rudder is required to prevent the left yaw from decreasing the rate of turn

ii. Left turn: Rudder compensates for left Turning Tendencies minus Adverse Yaw
   a. Adverse yaw counteracts some of the left turning tendencies
   b. Less right rudder is required than in a right turn
C. In the climbing right turn, the controls are slightly crossed because of the need for left aileron pressure to prevent overbanking and right rudder to overcome the left turning tendencies

5. Overbanking Tendency AI.IX.D.K2

A. During a turn, the wing on the outside travels a longer path relative to the wing on the inside of the turn
   i. As turn radius becomes smaller, a significant difference develops between these two paths
      a. The smaller the turn radius, the faster the outside wing moves relative to the inside wing
   ii. Because the outside wing is traveling faster than the inside wing, it also develops more lift
      a. Creates an overbanking tendency that is controlled with aileron in the opposite direction of the turn
      b. Creates more drag on the outside wing resulting in a slight slip that must be corrected with rudder



B. Overbanking and Stability
   i. Overbanking doesn't occur during every turn due to the aircraft's inherent stability characteristics
      a. Positive static stability tries to return the aircraft to its original state, in this case zero bank/straight flight
      b. The additional lift on the outside wing tries to roll the aircraft to a higher bank angle
   ii. Low Bank: Positive static stability outweighs the small difference in speed between wings and the aircraft tends to return to wings level
      a. Aileron must be held in the direction of the turn to maintain bank
   iii. Medium Bank: Positive static stability balances lift generated by the outside wing
      a. Hypothetically, aileron could be removed, and the aircraft would maintain the bank angle
   iv. Steep Bank: The outer wing's lift is too great for the stability and the aircraft continues to roll into the turn
      a. Aileron must be applied opposite the direction of the turn to maintain the bank angle
C. Overbanking Tendency and the Lazy Eight
   i. When in a nose high turning attitude at a slow airspeed, as at the top of the maneuver, bank will increase
   ii. Use opposite aileron to maintain desired bank angle and prevent overbanking (most noticeable at 90°)

6. Summary

A. The maneuver requires constantly changing control pressures
   i. It is not possible to do a lazy eight mechanically because the control pressures required for perfect coordination are never the same
   ii. At no time is the maneuver flown straight and level
B. The pilot must learn to divide attention and plan for each segment of the lazy eight
   i. Divide attention between inside and outside references
      a. Do not fixate – Move between outside references, pitch, bank, airspeed, coordination
      b. The more experience with lazy eights, the more time you can spend on outside references
   ii. Preplan the events in each 45° segment
      a. Talk through the maneuver at each 45° point. Know what you're going to do
         - Altitude targets, Airspeed, Pitch, Bank
C. Unsymmetrical Loops
   i. Properly plan pitch and bank attitude changes
      a. Don't pitch up or down excessively
         - Aggressive pitch up could result in the airspeed getting too slow too early, or a potential stall
         - Aggressive pitch down could lead to excessive speed
            a Greater than the maneuver starting speed and/or V_A

b. Bank control
  - Adjust bank to hit the proper bank angles at the reference points
  - Anticipate and compensate for changing airspeeds and the over banking tendency

7. Common Errors AI.IX.D.K5

A. Not clearing the area
B. Maneuver is not symmetrical across each 180°
C. Inadequate or improper selection or use of 45°, 90°, 135° references
D. Ineffective planning
E. Gain or loss of altitude at each 180° point
F. Poor control at the top of each climb segment resulting in the pitch rapidly falling through the horizon
G. Airspeed or bank angle standards not met
H. Control roughness
I. Poor flight control coordination
J. Stalling at any point during the maneuver
K. Execution of a steep turn instead of a climbing maneuver
L. Not scanning for other traffic during the maneuver
M. Performing by reference to the flight instruments rather than visual references

8. RM: Hazards

A. Accelerated Stalls AI.IX.D.R7
   i. At the same gross weight, configuration, and power, an aircraft will consistently stall at the same indicated airspeed if no acceleration is involved, but the aircraft will stall at a higher indicated airspeed when excessive maneuvering loads are imposed on it
      a. Pitching and rolling actions tend to be more sudden
   ii. Recovery
      a. Promptly release back elevator pressure, increase power, return to straight and level, coordinated flight
   iii. Accelerated Stalls and Lazy Eights
      a. Use smooth, controlled inputs. Avoid aggressive/excessive control inputs, especially close to the ground
      b. Fly it as described, lazy - Smooth and controlled, not aggressive
B. Dividing Attention AI.IX.D.R1
   i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
      a. Constantly changing control forces requires effective attention management
   ii. Divide attention between aircraft control and orientation
      a. Orientation is not just aircraft attitude, but also where you are and what or who is around you
   iii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety comes first

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.D.R4
B. IX. RM Concepts – Low Altitude Maneuvering AI.IX.D.R3
C. IX. RM Concepts – Collision Hazards AI.IX.D.R2

Conclusion:
Brief review of the main points
It is important that each part of the maneuver is performed at the same speed, or, increases and decreases in both pitch and bank should be made at the same rate during each part of the turn. Each part of the turn should be a mirror image of its opposite. It also is very important to keep the airplane coordinated throughout the varying attitudes and airspeeds in the maneuver.

Commercial Pilot ACS Skills Standards

1. Approximately 30° bank at the steepest point
2. Altitude at 180° point, ±100 feet from entry altitude
3. Airspeed at the 180° point, ±10 knots from entry airspeed
4. Heading at the 180° point, ±10 degrees

IX.E. Ground Reference Maneuvers

The ACS combines Rectangular Course, S-Turns, and Turns Around a Point into a single task. We've kept them as individual lessons.

- **Rectangular Course**
- **S-Turns**
- **Turns Around a Point**

IX.E. Rectangular Course

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of the rectangular course and the elements involved in maintaining a proper ground track. The learner can perform the maneuver as required in the ACS.
Key Elements	1. Plan Ahead 2. Wind Corrections 3. Coordination
Elements	1. The Basics 2. Performing the Rectangular Course 3. Common Errors 4. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands how wind can affect the ground track of the airplane and can make the necessary corrections to maintain a uniform ground track, especially in the traffic pattern.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This maneuver will make the traffic pattern much more natural and easier…

Overview

Review Objectives and Elements/Key ideas

What

A training maneuver in which the ground track of the airplane is equidistant from all sides of a selected rectangular area on the ground.

Why AI.IX.E.K1

This maneuver simulates the conditions encountered in a traffic pattern and therefore prepares the student for traffic pattern work. It assists in:

- Maintaining a relationship between the plane and ground
- Dividing attention between the flightpath, ground-based references, manipulating the flight controls, and scanning for outside hazards and instrument indications
- Adjusting the bank angle during turns to correct for groundspeed changes to maintain constant radius turns
- Rolling out from a turn with the required wind correction angle to compensate for drift
- Establishing and correcting the wind correction angle to maintain the track over the ground
- Preparing the pilot for the airport traffic pattern and subsequent landing practice

How:

1. **The Basics** AI.IX.E.K2, AI.IX.E.K3, AI.IX.E.K4
    A. The rectangular course is designed to replicate a traffic pattern
    B. The aircraft should be flown parallel to, and at a uniform distance, about ½ to ¾ mile, from the boundaries
        i. The references should be easily observable from both seats
            a. Do not fly directly above the boundaries since this will not provide useable reference points for turning
        ii. Not too close to the boundaries to avoid very steep bank angles
    C. All turns should be started and completed at the field boundaries (see maneuver picture)
        i. The closer the aircraft is to the boundaries, the steeper the bank necessary at the turning points
            a. Airplane Flying Handbook: Limit bank to a maximum of 45° during any ground reference maneuver
            b. May be more practical to practice at the traffic pattern limit of 30° of bank to establish good habits
    D. Turn Rate & Radius Recap
        i. Rate of Turn
            a. The rate of turn is the number of degrees per second the aircraft is turning
            b. Rate of turn is affected by both the bank angle and airspeed
                - As bank angle increases, so does the rate of turn
                - As airspeed increases, the rate of turn decreases
                - Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn
        ii. Radius of Turn
            a. The radius of a turn describes the size of circle an aircraft would fly during a turn
                - The radius is a measurement taken from the center of the circle to any point on the circle
            b. Radius of turn is also affected by both the bank angle and airspeed (but opposite to Rate of Turn)
                - As bank angle increases, the radius of turn decreases

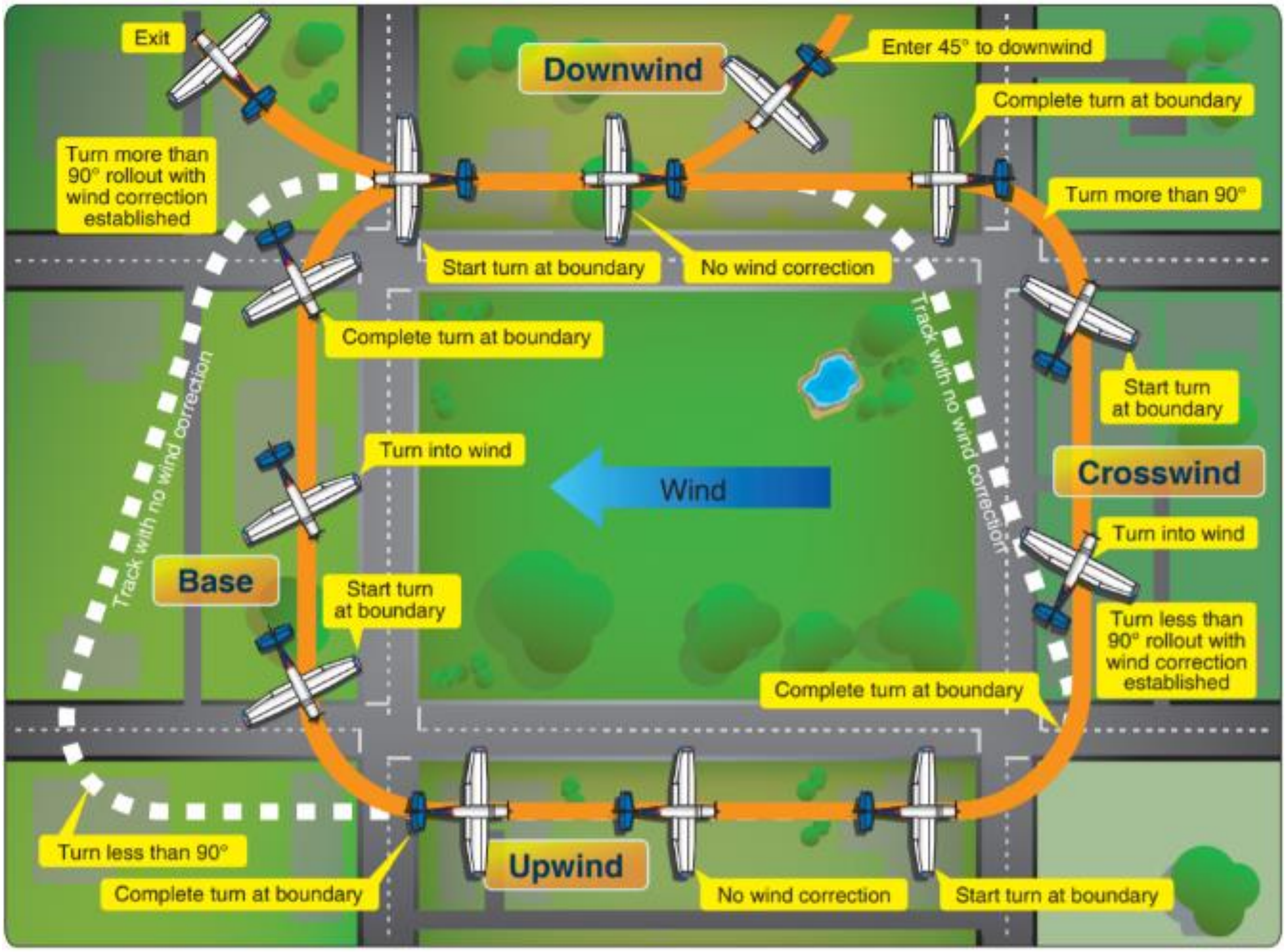
- As airspeed increases, the radius of turn increases
  a Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn

E. Wind Correction
   i. To maintain a course parallel/of equal distance to the boundaries wind must be accounted for throughout the maneuver
   ii. Whenever there is any crosswind, the airplane will have to be crabbed into the wind
      a. Use coordinate flight controls to point the aircraft into the wind
      b. Note the aircraft's position in relation to the reference field, and adjust the crab as necessary to maintain that distance
   iii. Roll Rate
      a. The rate of roll in/out of the turn will need to be adjusted to prevent drifting in or out of the course
         - When the wind is from a direction that drifts the airplane into the course, use a slow roll rate
         - When the wind is from a direction that drifts the airplane outside the course, roll rate should be high
   iv. Bank Angle
      a. The amount of bank used in each turn will vary depending on groundspeed
      b. The faster the groundspeed (tailwind), the steeper the bank required to maintain the ground track
      c. The slower the groundspeed (headwind), the shallower the bank required to maintain the ground track
      d. As groundspeed changes during a turn, bank angle will have to change with it
         - If the groundspeed is initially higher and then decreases through the turn, the bank angle should progressively decrease throughout the turn
         - If the groundspeed is initially slower and then increases through the turn, the bank angle should progressively increase through the turn, until rollout is started
      e. During turns, to maintain altitude, back pressure will need to be increased
      f. Use visual references and the instrument indications to maintain course and altitude
   v. Other Considerations
      a. Stay ahead of the aircraft and know what is coming next
      b. Do not use rudder to help the aircraft around the corner or to crab

F. RM: Coordination (RM: Uncoordinated flight) AI.IX.E.R5
   i. The airplane must remain in coordinated flight at all times
      a. Don't use the rudder to correct for wind drift, turn the plane with coordinated controls
      b. Don't use the rudder to encourage a turn, this could result in a dangerous crossed-control situation

G. Airspeed
   i. Maintained by increasing or decreasing power as necessary
   ii. ACS requires the pilot to maintain airspeed ± 10 knots

H. RM: Division of Attention AI.IX.E.R1
   i. The maneuver requires you to divide attention between the leg distance, turns, altitude, and airspeed
      a. Plan ahead and do not focus on one part of the maneuver (e.g. watching the ground)
   ii. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
      a. Over concentration inside or outside will result in the other being neglected and a poor maneuver
      b. Allows the pilot to divide attention between aircraft control and the orientation
         - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)
   iii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety first
   iv. Poor planning, orientation, or division of attention leads to poorly executed turns and wind correction



2. Performing the Rectangular Course AI.IX.E.K1

A. Selecting a Suitable Altitude
   i. Entry altitude should be 600' - 1,000' AGL (per the ACS)
      a. ± 100' restrictions
         - At 600' AGL, there is no room for error below; At 1,000' AGL, there is no room above
         - 800'AGL is a good altitude (slight difference than most normal patterns flown at 1,000')

B. Selecting a Suitable Reference
   i. A square or rectangular field, or an area with suitable ground references on all four sides should be selected
      a. Like a traffic pattern, the sides should be 5,000 – 10,000' in length (one to two miles)
   ii. Wind direction must be estimated (METAR, blowing smoke, water, trees, fields, or a 360° turn noting ground track)
      a. Per the ACS, the maneuver should be entered on a 45° angle to the downwind leg
   iii. Only use references clear of populated areas, obstructions, and anything that could pose a hazard
   iv. The reference should allow for a nearby landing area in case of an emergency during the maneuver

C. Prior to Entry
   i. *Pre-Maneuver Checklist - Lights ON; Fuel Pump ON; Mixture FULL RICH; Gauges GREEN
   ii. Clearing Turns
   iii. *Airspeed - 95 knots and trimmed for hands off, level flight
   iv. Orientation - Orient yourself in relation to the wind, plan to enter on a 45° entry to the downwind

D. The Maneuver

i. Entry is made at a 45° to the downwind (like a traffic pattern)
    a. Upon reaching ½ to ¾ miles from the field, turn to a downwind heading, parallel to the field
ii. Downwind Leg
    a. Since the airplane has a direct tailwind, no wind correction is needed
        - If the wind isn't a perfect tailwind, point the airplane into the wind as necessary to maintain the ground track
    b. Anticipate and visualize the turn to the base leg
        - The turn:
            a High roll rate
            b Steepest bank transitions to medium bank
            c Greater than 90° turn
        - Roll Rate
            a A high roll rate is required to prevent the tailwind from pushing the aircraft away from the track
        - Bank
            a Remember, as groundspeed changes in a turn, bank must change with it to maintain the track
                1. At the beginning of the turn, the airplane has the strongest tailwind and therefore the highest groundspeed. Bank will be the steepest
                2. As the turn progresses, the tailwind transitions to a crosswind. Groundspeed is decreasing; therefore, bank will decrease as the airplane makes its way around the turn
        - Roll Out/Amount of Turn
            a On the base leg, the crosswind will tend to push the aircraft away from the field
            b To compensate for the drift, the turn to the base leg will have to be more than 90°, and a crab will have to be established into the wind
                1. When rolling out onto this leg, the airplane will be turned slightly toward the field/into the wind
                    a. The amount of crab will vary based on the strength of the wind
                        i. Adjust the crab based on movement toward or away from the field
iii. Base Leg
    a. Divide attention between outside/inside references to maintain altitude & distance from the reference
    b. The base leg is continued with the aircraft turned toward the field/into the wind until the upwind leg boundary is being approached
    c. Anticipate and visualize the turn to the upwind leg
        - The turn:
            a High roll rate
            b Medium bank transitions to shallow bank
            c Less than 90° Turn
        - Roll Rate
            a Since the wind is from a direction that will drift the aircraft toward the outside of the course, the roll rate should be high
        - Bank
            a Remember, as groundspeed changes in a turn, bank will have to change to maintain track
                1. At the beginning of the turn, the airplane is experiencing a crosswind (no headwind or tailwind) and therefore an average groundspeed. Begin the turn with a medium bank angle
                2. As the turn progresses, the crosswind transitions into a headwind. Groundspeed is decreasing; therefore, bank will decrease as the airplane makes its way around the turn
        - Roll Out/Amount of Turn
            a On the upwind leg, the headwind will not affect the aircraft's drift in relation to the desired

track. Roll out to parallel the upwind leg reference

b Because the aircraft was pointed toward the field when the turn was started, less than 90º of turn is required to rollout on the upwind leg

c If the wind is not a perfect headwind, adjust the crab as necessary to maintain course

iv. Upwind Leg
   a. On the upwind leg, no wind correction is needed as the plane is headed directly into the wind
      - Adjust as necessary if the wind isn't a perfect headwind
   b. Use visual references to maintain altitude and heading, cross check with the instruments
   c. Anticipate and visualize the turn to the crosswind leg
      - The Turn:
         a Low roll rate
         b Shallow bank transitions to medium bank.
         c Less than 90º Turn
      - Roll Rate
         a Because the wind is from a direction that will drift the aircraft into the course, a low roll rate should be used to enter the turn
      - Bank
         a At the beginning of the turn, the airplane is experiencing a headwind and therefore the slowest groundspeed. Begin the turn with a shallow bank angle
         b As the turn progresses, the headwind transitions into a crosswind. Groundspeed is increasing; therefore, bank will increase as the airplane makes its way around the turn
      - Roll Out/Amount of Turn
         a On the crosswind leg, the crosswind will tend to push the aircraft toward the field
            1. To compensate for the drift, the turn to the base leg will have to be less than 90º, and a crab will have to be established into the wind
            2. When rolling out onto this leg, the airplane will be turned slightly away from the field/into the wind
               a. The amount of crab will vary based on the strength of the wind
                  i. Adjust the crab based on movement toward or away from the field

v. Crosswind Leg
   a. While on the crosswind leg, the wind correction angle should be adjusted to keep proper distance
   b. Anticipate and visualize the turn back to the downwind leg
      - The turn:
         a Low roll rate
         b Medium bank transitions to steepest bank
         c More than 90º Turn
      - Roll Rate
         a Because the wind is from a direction that will cause the aircraft to drift into the course, a low rate of roll should be used
      - Bank
         a At the beginning of the turn, the airplane is experiencing a crosswind and therefore an average groundspeed. Begin the turn with a medium bank angle
         b As the turn progresses, the crosswind transitions into a tailwind. Groundspeed is increasing; therefore, bank will increase as the airplane makes its way around the turn
      - Roll Out/Amount of Turn
         a On the downwind leg, the aircraft will have a tailwind and should not require drift correction
            1. The aircraft will be turned to rollout parallel to the reference line

2. Because the aircraft was pointed away from the field when the turn was started, the turn will have to be greater than 90º to roll out parallel to the reference line

vi. Exit on the downwind leg

vii. Anomalies

a. In a perfect scenario, drift is not encountered on the upwind/downwind legs
   - It may be difficult to find a situation where the wind is blowing exactly parallel to the boundaries
   - Therefore, slight wind correction may be necessary on all the legs

3. Common Errors AI.IX.E.K5

A. Failure to adequately clear the surrounding area for safety hazards, initially and throughout the maneuver.
B. Failure to establish a constant, level altitude prior to entering the maneuver.
C. Failure to maintain altitude during the maneuver.
D. Failure to properly assess wind direction.
E. Failure to establish the appropriate wind correction angle.
F. Failure to apply coordinated aileron and rudder pressure, resulting in slips and skids.
G. Failure to manipulate the flight controls in a smooth and continuous manner.
H. Failure to properly divide attention between airplane control and orientation with ground references.
I. Failure to execute turns with accurate timing.

4. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.E.R4
B. IX. RM Concepts – Low Altitude Maneuvering AI.IX.E.R3
C. IX. RM Concepts – Collision Hazards AI.IX.E.R2

Conclusion:

Brief review of the main points

It is important to anticipate turns to correct for ground speed, drift, and turning radius. When wind is with the plane, turns must be steeper; when it's against, turns must be slow/shallow. The same techniques apply in traffic patterns.

Private Pilot ACS Skills Standards

1. Rectangular course: enter a left or right pattern, 600 to 1,000 feet above ground level (AGL) at an appropriate distance from the selected reference area, 45° to the downwind leg
2. Maintain altitude ±100 feet; maintain airspeed ±10 knots.

IX.E. S-Turns

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of S-turns as described in the ACS.
Key Elements	1. Wind Correction 2. Coordination 3. Emergency Landing Area
Elements	1. Purpose of S-turns 2. The Basics 3. Performing S-Turns 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the effect of wind on maintaining equilateral radii on each side of a reference line. They can make the necessary adjustments through the turns due to the airplane's changing position in relation to the wind.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This maneuver will provide a much better understanding of how the wind effects turning the airplane. And, it's considered to be easier than the rectangular course you already learned.

Overview

Review Objectives and Elements/Key ideas

What

A maneuver in which the airplane's ground track describes semicircles of equal radii on each side of a selected straight line on the ground

Why

To understand and learn to adjust for winds and their effect on the aircraft's ground track throughout turns in opposite directions.

How:

1. **Purpose of S-turns** AI.IX.E.K1
   - Maintain a relationship between the plane and ground
   - Divide attention between the flightpath, ground references, the flight controls, scanning for outside hazards, and instrument indications
   - Adjust bank during turns to correct for groundspeed changes to maintain constant radius turns
   - Roll out from a turn with the required wind correction angle to compensate for any wind drift
   - Establish and correct the wind correction angle to maintain track over the ground
   - Compensate for drift in quickly changing orientations
   - Arrive at specific points on required headings

   A. They present a practical application for the correction of wind during a turn

   B. All these abilities are useful throughout your flying career and when practiced enough will become second nature, encouraging further development in more advanced maneuvers and safe, competent flying
2. **The Basics** AI.IX.E.K2, AI.IX.E.K3

   A. The Maneuver

   i. The maneuver consists of crossing the reference line at a 90° angle (perpendicular) on a downwind, and immediately beginning a 180°, constant radius turn in one direction

   ii. The pilot should reference the airplane's nose and wingtips, and the ground references and adjust the rollout so that the airplane crosses the straight-line ground reference with the wings level, at the proper heading (opposite the entry heading), altitude, and airspeed

   iii. As the airplane crosses the reference line, the pilot should immediately begin a 180°, constant radius turn in the opposite direction

   B. Turn Rate & Radius Recap

   i. Rate of Turn

   a. The rate of turn is the number of degrees per second the aircraft is turning

   b. Rate of turn is affected by both the bank angle and airspeed
      - As bank angle increases, so does the rate of turn
      - As airspeed increases, the rate of turn decreases
      - Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn

   ii. Radius of Turn

a. The radius of a turn describes the size of circle an aircraft would fly during a turn
    - The radius is a measurement taken from the center of the circle to any point on the circle

b. Radius of turn is also affected by both the bank angle and airspeed (but opposite to Rate of Turn)
    - As bank angle increases, the radius of turn decreases
    - As airspeed increases, the radius of turn increases
        - a Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn

C. To maintain the constant radius for each turn, the pilot constantly adjusts roll rate and bank angle for the effects of wind and changing groundspeed

i. Roll Rate

a. The rate of roll in/out of the turn will need to be adjusted to prevent drifting in or out of the course
    - When the wind is from a direction that could push the airplane away from the reference line (and the aircraft has a high groundspeed), the rate of roll should be high/
        - a Ex: Entering the maneuver on the downwind leg
    - When the wind is from a direction that could take the aircraft toward the reference line (and the aircraft has a lower groundspeed), the roll rate should be slow
        - a Ex: Starting the second turn, on the upwind leg

ii. Bank Angle

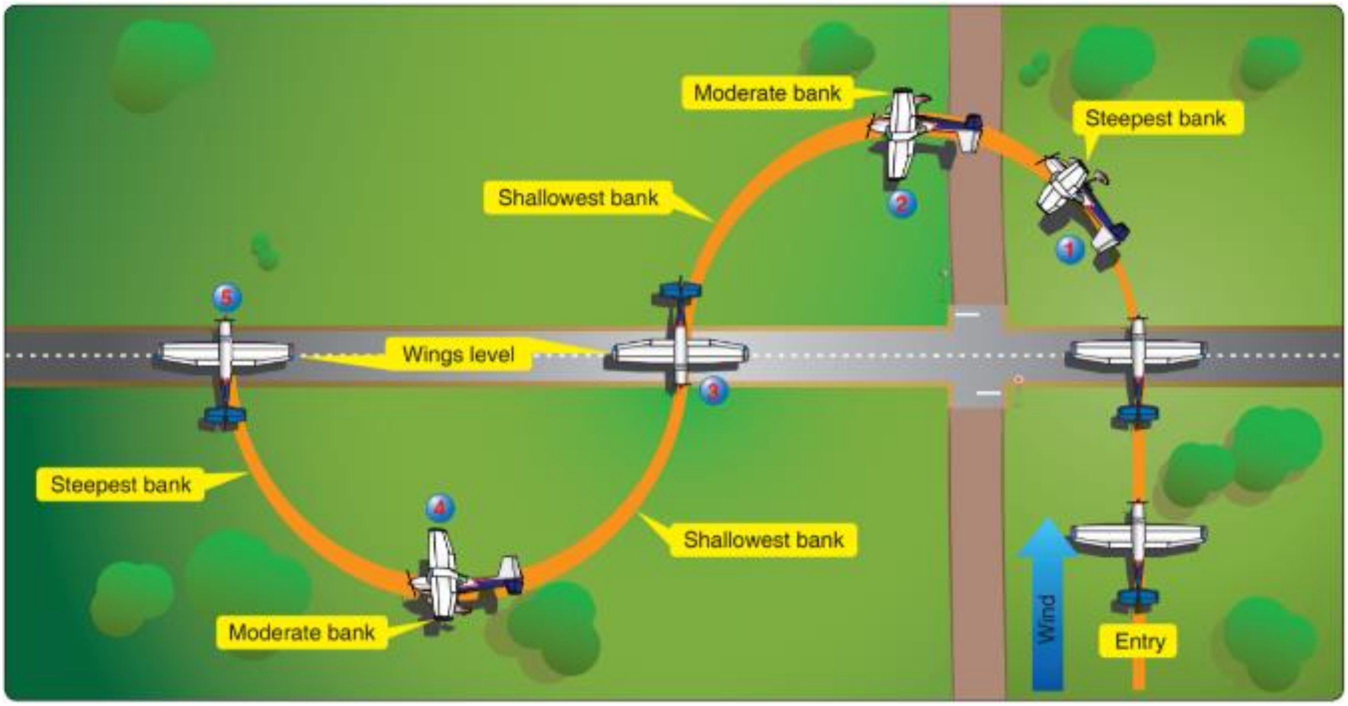
a. As groundspeed increases, bank angle will need to increase, and as groundspeed decreases, bank angle will need to decrease
    - For example, when starting the maneuver on the downwind (highest groundspeed), bank starts the steepest and is gradually shallowed as the aircraft turns into the wind and groundspeed decreases
    - The opposite occurs on the second turn as the headwind transitions back into a tailwind

iii. Wind Correction Angle

a. In addition to the rate of roll and bank angle, the pilot must also control the wind correction angle to maintain a constant radius
    - For example, if the pilot starts the maneuver with a left turn, and the airplane is exactly crosswind, at the 90^o point of the turn, with a crosswind requiring 10^o wind correction angle, the airplane would be flying a heading that is 10^o ahead when directly over the 90^o ground reference point. In other words, to compensate for the crosswind and prevent the aircraft from being pushed away from the reference line, the first 90^o track over the ground would result in a heading change of 100^o, and the last 90^o track over the ground would result in 80^o of heading change
    - In the second turn, to the right, the heading change would be the reverse. The first 90^o of turn would result in 80^o of heading change, and the second 90^o of turn would result in 100^o of heading change

b. The wind correction angle varies with the strength of the crosswind
    - The stronger the crosswind, the greater the wind correction angle required
    - The wind correction angle will increase from the start of the turn to the 90^o point (max crosswind), and then decrease from the 90^o point to the rollout

iv. Poor planning, orientation, or division of attention leads to poorly executed turns and wind correction.



3. Performing S-Turns AI.IX.E.K1

A. Prior to Entry
   i. Select a Suitable Altitude
      a. Entry altitude should be 600’-1,000’ AGL per the ACS
         - ± 100’ restrictions
            a At 600’ AGL, there is no room for error below; At 1,000’ AGL, there is no room above
            b 800’AGL is a good altitude
   ii. Select a Suitable Reference Line
      a. A ground based straight line reference that is perpendicular to the wind should be selected
         - Options include roads, train tracks, fence lines, etc.
            a Something straight, perpendicular to the wind, long enough to make two turns over, easy to see
      b. Estimate wind direction (METAR, blowing smoke, water, trees, fields, or a 360 noting ground track)
         - Maneuver is entered on the downwind, crossing perpendicular to the ground reference line
      c. Only use references clear of populated areas, obstructions, and anything that could pose a hazard
      d. The reference should allow for a nearby landing area in case of an emergency during the maneuver
   iii. *Pre-Maneuver Checklist - Lights ON; Fuel Pump ON; Mixture FULL RICH; Gauges GREEN
   iv. Clearing Turns
   v. *Airspeed - 95 knots and trimmed for hands off, level flight

B. The Maneuver
   i. Entry
      a. The road/line should be approached on the downwind (perpendicular to the line), 800’ AGL
         - Minimize your workload – enter the maneuver on airspeed and altitude, and trimmed for level flight
      b. Ensure entry on the downwind (with a tailwind), perpendicular to the reference line
         - Standard practice to enter ground reference maneuvers on downwind with highest groundspeed
      c. Set yourself up for success
         - Give yourself the time and distance necessary to maneuver the aircraft and set up for the entry
   ii. Downwind Side of the Turn (1st Half)

a. General
- Highest ground speed (tailwind) at the start of the turn, transitioning to the lowest ground speed (headwind) at the end of the turn
- Highest bank angle and rate of roll at the start of the turn, decreasing throughout to maintain a constant radius
- The first turn establishes the radius for the second turn

b. Bank Angle and Roll Rate
- Due to the high groundspeed, the roll into the turn must be rapid, and the angle of bank must be the steepest
  - a A normal rate of roll at these speeds will result in the aircraft being pushed farther away from the reference line, hindering the pilot's ability to maintain a constant radius
- As the turn progresses and airspeed decreases, the bank angle and rate of rollout must be decreased
  - a If bank was not decreased, the turn would get progressively tighter as groundspeed decreased
- At the 90° crosswind position, the airplane should also have the correct crosswind correction angle
  - a This will vary based on the strength of the crosswind

c. Completing the Turn
- The pilot should reference the airplane's nose and wingtips, and the ground references and adjust the rollout so that the airplane crosses the ground reference line with the wings level, at the proper heading (opposite the entry heading), altitude, and airspeed

iii. Upwind Side of the Turn (2nd Half)

a. General
- At the instant the road is crossed, a turn in the opposite direction should be started
- Slowest groundspeed (headwind) at the start of this turn, transitioning back to the highest groundspeed (tailwind) at the end of the turn
- To maintain the constant radius turn, a shallow bank angle and slow rate of roll is required at the start of the turn, increasing throughout the turn as groundspeed increases

b. Bank Angle and Roll Rate
- Since the aircraft is flying into a headwind (slowest groundspeed) when this turn starts, the rate of roll must be smooth and gentle, and the bank angle shallow
  - a This prevents a tight turn in relation to the reference line (smaller radius than the first turn) and being unable to complete 180° of turn before re-crossing the reference line
  - b Visualize the turn, and increase bank slowly during the early part of the turn
- As the turn progresses, the headwind slowly transitions to a crosswind and then a tailwind, meaning the rate of roll and bank angle need to be increased as groundspeed increases to maintain a symmetrical ground track
- At the 90° crosswind position, the airplane should also have the correct crosswind correction angle
  - a This will vary based on the strength of the crosswind

c. Completing the Turn

d. Again, the rollout must be timed so straight-and-level is reached over and perpendicular to the road
- Judge the closure rate and increase bank to cross wings level

C. Maintaining a Constant Altitude

i. The pilot should maintain altitude ± 100' per the ACS

ii. Trim the aircraft for level flight prior to starting the maneuver

iii. As bank increases, back elevator pressure will need to be increased to maintain altitude

a. Divide your attention, don't fixate on just the turn radius

D. Maintaining a Constant Airspeed

i. A constant power setting and a stable altitude go a long way in maintaining a constant airspeed
   a. Power may have to be adjusted as bank and back elevator pressure increase due to increased drag
      - Again, divide your attention, don't fixate, and adjust power as necessary to maintain airspeed

ii. Don't fixate: Divide attention between the turn and wind, flying the aircraft, and your surroundings
   a. Small, frequent corrections are much more effective than large infrequent corrections

iii. Understand your aircraft
   a. The more you fly, the more you'll know what to expect from your aircraft
      - i.e. the amount of back pressure required to maintain level flight in differing amounts of bank, or when and how much power is required to maintain a constant airspeed

E. RM: Coordination (RM: Uncoordinated flight)
   i. As in all phases of flight, it is important to maintain proper coordination
      a. Do not use uncoordinated rudder to fix the radius of the turn or to force the aircraft to cross perpendicular to the reference line as this could result in a dangerous cross-controlled situation
   ii. RM: Uncoordinated use of flight controls AI.IX.E.R5
      a. Often pilots can try to cheat the turn with rudder to adjust the radius or cross the reference line on a perpendicular track
         - Not only does this defeat the purpose of S-turns, but it also can put the aircraft in to a dangerous cross-controlled situation
      b. Maintain coordination and adjust the bank angle and roll rate to fix the turn radius

4. Common Errors AI.IX.E.K5

A. Failure to adequately clear surrounding area for safety hazards, initially and throughout the maneuver.
B. Failure to establish a constant, level altitude prior to entering the maneuver.
C. Failure to maintain altitude during the maneuver.
D. Failure to properly assess wind direction.
E. Failure to properly execute constant radius turns.
F. Failure to manipulate the flight controls in a smooth and continuous manner when transitioning into turns.
G. Failure to establish the appropriate wind correction angle.
H. Failure to apply coordinated aileron and rudder pressure, resulting in slips or skids

5. RM: Hazards

A. Division of Attention AI.IX.E.R1
   i. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
      a. Over concentration inside or outside will result in the other being neglected and a poor maneuver
      b. Allows the pilot to divide attention between aircraft control and the orientation
         - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)
   ii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety first

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.E.R4
B. IX. RM Concepts – Low Altitude Maneuvering AI.IX.E.R3
C. IX. RM Concepts – Collision Hazards AI.IX.E.R2

Conclusion:
Brief review of the main points
Bank is constantly changing to track a constant radius turn on each side of the reference line as the airplane's position relative to the wind is changing.

Private Pilot ACS Skills Standards

IX.E. S-Turns

1. S-turns: enter perpendicular to the selected reference line, 600 to 1,000 feet AGL at an appropriate distance from the selected reference area
2. Maintain altitude ±100 feet; maintain airspeed ±10 knots.

IX.E. Turns Around a Point

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should exhibit knowledge regarding the performance of a Turn Around a Point. Knowledge will include the elements listed below. Performance of the maneuver should be to ACS standards.
Key Elements	1. Increased Groundspeed = Increased Bank 2. Decreased Groundspeed = Decreased Bank 3. Maintain Coordination
Elements	1. Purpose 2. The Basics 3. Performing Turns Around a Point 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner can demonstrate knowledge and proficiency in turns around a point. The learner understands the effect of wind on an aircraft's course over the ground primarily during a turn.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This exercise shows the difference between the aircraft's motion in the air, and its ground track. These are different because the aircraft is subject to the moving air mass in which it flies. If wind exists, a ground track with constant radius will require a constantly changing bank angle to correct for wind.

Overview

Review Objectives and Elements/Key ideas

What

The airplane is flown in two or more complete circles of uniform radii or distance from a prominent ground reference point using a maximum bank of approximately 45° while maintaining a constant altitude.

Why

To learn to adjust for wind and its effect on the aircraft's ground track as throughout turns

How:

1. **Purpose of Turns Around a Point** AI.IX.E.K1

- Maintain a specific relationship between the airplane and the ground
- Divide attention between the flightpath, ground-based references, manipulating the flight controls, and scanning for outside hazards and instrument indications
- Adjust the bank angle during turns to correct for groundspeed changes to maintain constant radius turns
- Improve competency in managing the quickly changing bank angles
- Establish and adjust the wind correction angle to maintain the track over the ground
- Compensate for drift in quickly changing orientations
- Develop further awareness that the radius of a turn is correlated to the bank angle

   A. All these abilities are useful throughout your flying career and when practiced enough will become second nature, encouraging further development in more advanced maneuvers and safe, competent flying

2. **The Basics** AI.IX.E.K2, AI.IX.E.K3
   A. The Maneuver
      i. Consecutive, constant radius 360° turns where, throughout the maneuver, the pilot must constantly adjust the bank angle and the rate of turn due to the wind's varying affect at different points in the turn
   B. Turn Rate & Radius Recap
      i. Rate of Turn
         a. The rate of turn is the number of degrees per second the aircraft is turning
         b. Rate of turn is affected by both the bank angle and airspeed
            - As bank angle increases, so does the rate of turn
            - As airspeed increases, the rate of turn decreases
            - Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn
      ii. Radius of Turn
         a. The radius of a turn describes the size of circle an aircraft would fly during a turn
            - The radius is a measurement taken from the center of the circle to any point on the circle
         b. Radius of turn is also affected by both the bank angle and airspeed (but opposite to Rate of Turn)
            - As bank angle increases, the radius of turn decreases

- As airspeed increases, the radius of turn increases
  - a Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn

C. Wind Correction
  i. Roll Rate
    a. The rate of rolling in and out of the turn will need to be adjusted to prevent drifting in or out of the desired radius
      - When the wind is from a direction that pushes the airplane away from the reference point (and the aircraft has a high groundspeed), the rate of roll should be high
        - a Ex: Entering the maneuver on the downwind leg
        - b A slow roll rate would increase the radius of the turn on the downwind side
      - When the wind is from a direction that could take the aircraft toward the reference line (and the aircraft has a lower groundspeed), the roll rate should be slow
        - a Ex: Starting the second half of the turn, into the wind
        - b A rapid roll rate in this situation would tighten the radius on the upwind side
  ii. Bank Angle
    a. To maintain a constant radius around the point, the pilot must adjust bank to compensate for changing groundspeeds
      - The higher the groundspeed (or the greater the tailwind), the higher the bank required to maintain the constant radius turn
      - The lower the groundspeed (or greater the headwind), the lower the bank required to maintain the constant radius turn
  iii. Wind Correction Angle
    a. In addition to the rate of roll and bank angle, the pilot must also control the wind correction angle to maintain a constant radius
      - For example, imagine starting the maneuver with a left turn, directly on the downwind. At the 90º point of the turn, the airplane is exactly crosswind, and experiencing a crosswind that requires 10 º of wind correction angle. To maintain the radius, the airplane would be flying a heading that is 10º ahead of the turn when directly over the 90º ground reference point. In other words, to compensate for the crosswind and prevent the aircraft from being pushed away from the reference point, the first 90 º track over the ground would result in a heading change of 100 º, and the second 90º track over the ground would result in 80 º of heading change

D. RM: Division of Attention AI.IX.E.R1
  i. The pilot must learn to divide attention between the reference point, the aircraft, what's coming next in the turn, and their surroundings
    a. Monitor the reference point to ensure the radius is being properly maintained
    b. Glance between inside and outside references to maintain airspeed, altitude, and coordination
    c. Look forward and prepare for what is coming next (for example, changing bank, wind correction, etc.)
    d. Always keep an eye out for other traffic or threats
      - As bank becomes shallower, use the increased field of view as an opportunity to check for traffic

E. Remember, the goal is to make a constant radius turn over the ground, and because the airplane is flying through a moving air mass, the pilot must constantly adjust the bank angle, roll rate, and wind correction angle

3. Performing Turns Around a Point AI.IX.E.K1

A. Prior to Entry
  i. Select a Suitable Altitude
    a. Entry altitude should be 600' - 1,000' AGL
      - ± 100' restrictions - 800' AGL is a good altitude
  ii. Select a Suitable Reference Point

a. The point should be:
   - Prominent and easily distinguishable by the pilot
   - Small enough to present precise reference
     a Ex: Isolated trees, crossroads, etc.
     b A pond is too big
     c Intersections are very good
       1. Especially 4-way intersections which provide 90° markers around the turn
b. Only use references clear of populated areas, obstructions, and anything that could pose a hazard
c. The reference should allow for a nearby landing area in case of an emergency during the maneuver

iii. Pre-Maneuver Checklist
iv. Clearing Turns
v. Airspeed
   a. At or below V_A - Trim the airplane for hands off level flight prior to entry

B. Entry Procedure
   i. Position the aircraft to enter the maneuver downwind, where the groundspeed is the highest, and at the proper distance from the point
      a. In general, enter abeam the point approximately ¼ to ½ mile radius from the point
      b. In a high wing airplane, the lowered wing may block the view of the ground reference point. To prevent this, the pilot may need to change the maneuvering altitude or turn radius
         - Ensure the reference point is visible at all times
      c. Provide yourself the time and distance required to properly setup for entry into the maneuver
         - Set yourself up for success, don't rush into the maneuver. Take the time to be established on altitude and airspeed, and trimmed for level flight
   ii. Note the entry heading
      a. Use it throughout the maneuver to maintain orientation and help in planning

C. The Turn
   i. Abeam the point
      a. Coordinated roll into the turn maintaining the ¼ to ½ mile reference with a steep bank angle (≤ 45°)
         - As bank is increased, back pressure will have to be increased to maintain altitude
   ii. First Half of the Turn (Downwind Half)
      a. Starts with the steepest bank and ends with the shallowest bank
      b. As the turn progresses, the aircraft begins with a tailwind which transitions to a crosswind, then a headwind – groundspeed progressively decreases through the turn
         - The bank angle should be gradually reduced to maintain the constant radius
           a As bank angle is reduced, less back pressure is needed to maintain altitude
      c. Progressively adjust the aircraft's heading toward the inside of the turn to establish a wind correction angle (or crab) and prevent being pushed outside of the circle
         - The crab increases until reaching the 90° point of the turn (or the maximum crosswind), and then decreases as the wind transitions away from a crosswind and into a headwind
         - As a rule, on the downwind half of the turn, the nose is turned toward the inside
      d. RM: Always keep the turn coordinated
         - As the bank is reduced, rudder pressure will reduce
         - RM: Uncoordinated flight AI.IX.E.R5
           a Defeats the purpose of turns around a point
           b Can place the aircraft in a cross controlled state close to the ground
      e. At the end of the first half of the turn, bank should be at its most shallow point, and the crab should be entirely removed

- The aircraft is in a direct headwind, therefore lowest groundspeed, and lowest bank angle
- A direct headwind requires no crab

f. Considerations
- Divide attention between the turn and the aircraft
- Be proactive in making changes
- As bank angle increases, increase back pressure, power may need to be increased as well

iii. Second Half of the Turn (Upwind Half)

a. Opposite of the first half - Slowly move from a shallow to steep bank

b. As the turn progresses, the aircraft will experience a headwind which transitions to a crosswind and then back to a tailwind
- As groundspeed increases, bank will need to increase to maintain the desired turning radius
  - a As the bank angle is increased, more back pressure is necessary to maintain altitude

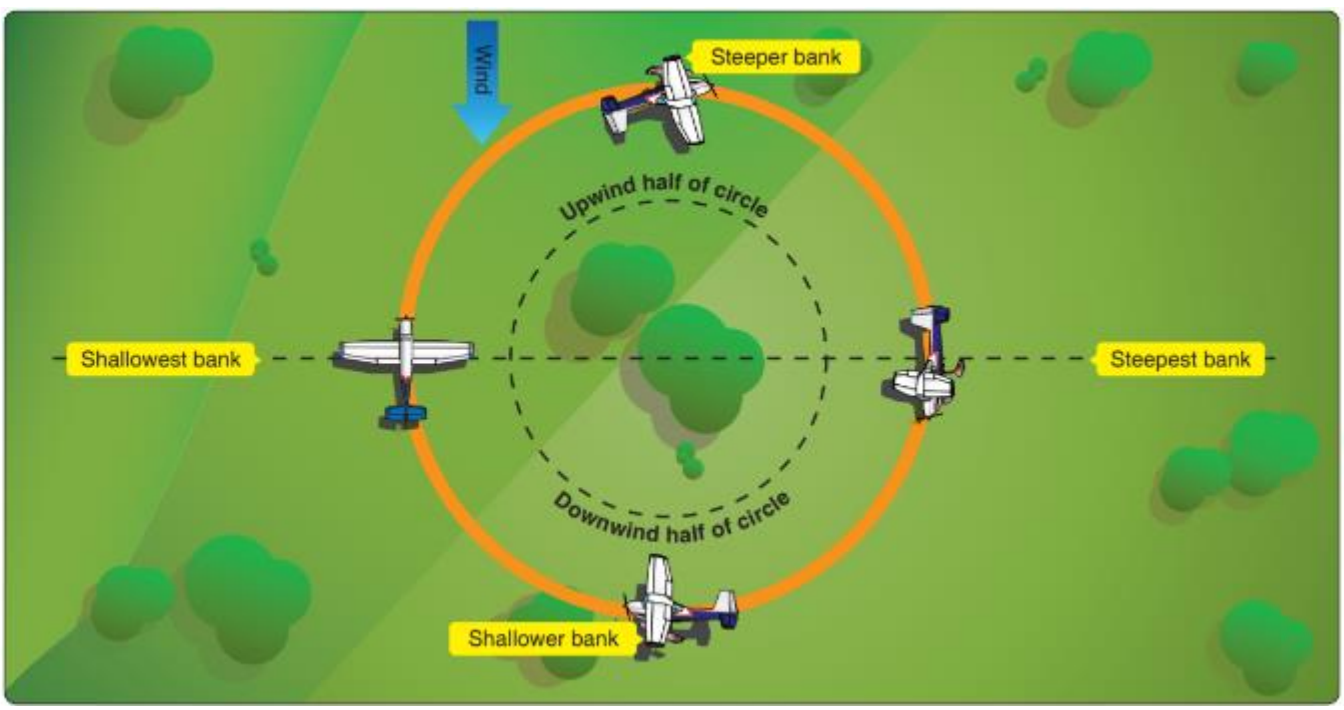
c. During the second half of the turn, the pilot should progressively adjust the aircraft's heading toward the outside of the turn to prevent being blown toward the reference point
- The crab increases until reaching the 90º point of the turn (or the maximum crosswind), and then decreases as the wind transitions away from a crosswind and into a tailwind
- As a rule, on the upwind half of the circle the nose is turned toward the outside

d. Always keep the airplane coordinated
- RM: Uncoordinated flight AI.IX.E.R5
- As bank is increased, rudder pressure will increase
- Do not use just rudder to adjust the turn radius

e. At the end of the second half, bank should return to the same angle used entering the maneuver
- The end of the second half places the aircraft at the starting point of the maneuver, with a tailwind
  - a Requires the steepest bank and no crab

D. Exit

i. Once at least 2 turns have been completed, initiate a smooth rollout on the initial entry heading



4. Recap

A. Theoretically, if there were no wind, bank would be constant all the way around the turn - no wind to correct for
   i. There also would be no need to crab
B. The stronger the wind, the more the bank angle will have to be varied throughout the maneuver
   i. Max bank angle should be no more than 45° at the steepest point
C. The steeper the bank, the more back pressure required to maintain altitude
D. Helpful to pick out targets along the flight path
   i. Such as barn, building, lake, etc. usually at ¼ intervals along the circle
      a. 4-way intersection is a very useful reference point
   ii. Helps to maintain the circle and ensures the airplane is in the right place at the right time

5. Common Errors AI.IX.E.K5

A. Failure to adequately clear the surrounding area for safety hazards, initially and throughout the maneuver.
B. Failure to establish a constant, level altitude prior to entering the maneuver.
C. Failure to maintain altitude during the maneuver.
D. Failure to properly assess wind direction.
E. Failure to properly execute constant radius turns.
F. Failure to manipulate the flight controls in a smooth and continuous manner.
G. Failure to establish the appropriate wind correction angle.
H. Failure to apply coordinated aileron and rudder pressure, resulting in slips or skids.

6. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.IX.E.R4
B. IX. RM Concepts – Low Altitude Maneuvering AI.IX.E.R3
C. IX. RM Concepts – Collision Hazards AI.IX.E.R2

Conclusion:

Brief review of the main points

This maneuver works to establish a better understanding of the airplane's turning tendencies due to changing crosswinds while helping the pilot learn to divide attention between controlling the airplane and other traffic.

Private Pilot ACS Skills Standards

1. Plan the maneuver:
   - Turns around a point: enter at an appropriate distance from the reference point, 600 to 1,000 feet AGL at an appropriate distance from the selected reference area
2. Maintain altitude ±100 feet; maintain airspeed ±10 knots.

IX.F. Eights on Pylons

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The learner should develop knowledge of the elements behind the Eights on Pylons maneuver and can perform the maneuver to ACS standards.
Key Elements	1. Points moves forward: Forward Pressure 2. Point moves backward: Backward Pressure 3. Small, coordinated corrections
Elements	1. What is Pivotal Altitude? 2. The Basics 3. Calculating Pivotal Altitude 4. Performing Eights on Pylons 5. Common Errors 6. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner understands Pivotal Altitude and the accompanying concepts to Eights on Pylons. The learner also can properly fly the maneuver.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The eights on pylons maneuver started in WWI. This maneuver was developed to maintain a constant view of a target, allowing the gunner to destroy a target. A more practical application now is keeping the wing out of the way for aerial photography.

Overview

Review Objectives and Elements/Key ideas

What

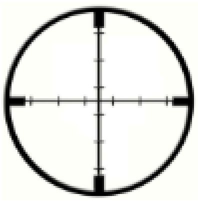
Eights on Pylons is an advanced maneuver in which the pilot's attention is directed at maintaining a pivotal position on a selected pylon, with minimum attention inside the flight deck.
The maneuver itself involves flying the airplane in a figure eight path around two selected points, or pylons, on the ground. However, no attempt is made to maintain a uniform distance from the pylon. Instead, the goal is to have an imaginary line that extends from the pilot's eyes to the pylon. This line must be imagined to always be parallel to the airplane's lateral axis. Along this line, the airplane appears to pivot as it turns around the pylon. In other words, if a taut string extended from the airplane to the pylon, the string would remain parallel to lateral axis as the airplane turned around the pylon. At no time should the string be at an angle to the lateral axis.

Why AI.IX.F.K1

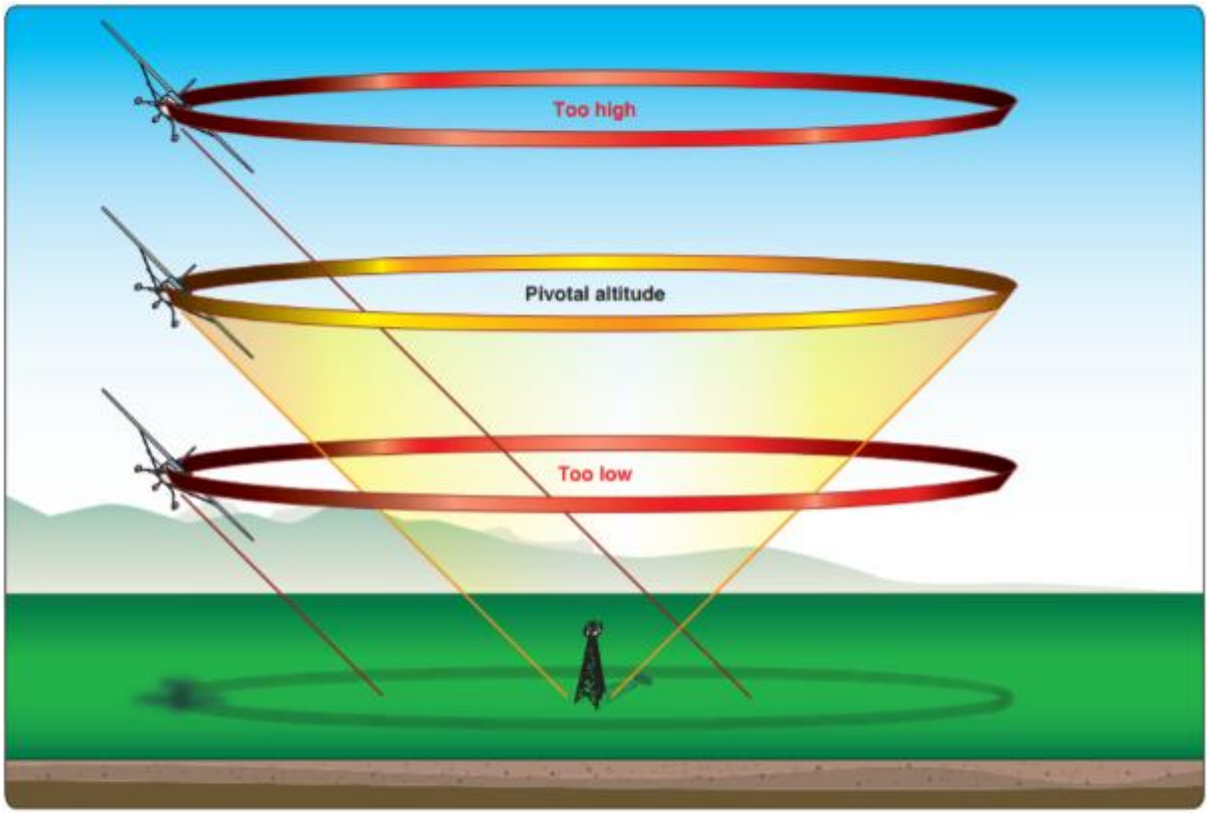
The objective of this maneuver is to develop the ability to maneuver the airplane accurately while dividing one's attention between the flight path and the selected points on the ground. Eights on Pylons are extremely helpful in teaching, developing, and testing subconscious control of the airplane.

How:

1. **What is Pivotal Altitude** AI.IX.F.K3
   A. General Description
      i. A specific altitude at which, for a given groundspeed, the projection of the visual reference line to the pylon appears to pivot
         a. Basically, the pivotal altitude is the altitude which keeps the pylon in the same position on the window (or other aircraft reference, like the wingtip) as the aircraft turns around it



            - Pivotal altitude varies with groundspeed
            - The reference line is parallel with the lateral axis of the airplane
               a *Off the wingtip in the case of the DA20
               b In a swept wing aircraft, there will be no wing reference, so the point must be kept in the same position on the window
                  1. The same as keeping the pylon in the center of a target on the window (image, left)
      ii. When turning at the pivotal altitude, the wingtip appears to be fixed to a single point on the landscape, but at any height other than the pivotal altitude, the wing tip appears to move across the landscape
         a. When turning at a height greater than the pivotal altitude, which is the normal situation in flight, the wingtip appears to move backward over the landscape
         b. When at a height less than pivotal altitude (close to the ground) the wingtip appears to move forward



2. The Basics AI.IX.F.K2, AI.IX.F.K3

A. Pivotal Altitude is Based on Groundspeed
  i. As groundspeed increases, pivotal altitude increases, vice versa
    a. Pivotal altitude does not change with bank
      - Distance from the pylon affects the angle of bank (more below)
  ii. Since the headings throughout the turns continually vary from directly downwind to directly upwind, the groundspeed will constantly change
    a. This will result in the pivotal altitude varying throughout the maneuver
      - The pilot must climb or descend to compensate for the changing groundspeed and to maintain the visual reference with the pylon
      - The change in altitude will depend on how much the wind affects groundspeed
        a Strong winds create larger changes in altitude than light winds
        b No wind would result in no change in altitude

B. Maintaining the Pivotal Altitude References
  i. Pitch
    a. As groundspeed decreases, pivotal altitude decreases
      - If no changes are made, as the aircraft slows it will be above the pivotal altitude
        a The wing will appear to move backward across the landscape
        b The point will move forward in relation to the wing
      - To compensate, the pilot must descend to maintain the reference line to the pylon
        a Airspeed increases slightly, increasing pivotal altitude
          1. In effect, we descend to the lower pivotal altitude, and the pivotal altitude comes up to us
      - General Rule: If the point moves FORWARD, apply FORWARD pressure
    b. As groundspeed increases, pivotal altitude increases as well
      - If no changes are made as the aircraft accelerates, it will be below the pivotal altitude

- a The wing will appear to move forward across the landscape
- b The point will move backward in relation to the wing
- To compensate, the pilot must climb to maintain the reference line to the pylon
  - a Airspeed decreases slightly, decreasing pivotal altitude
    1. In effect, we climb to the higher pivotal altitude, and the pivotal altitude comes down to us
- General Rule: If the point moves BACKWARD, apply BACK pressure

c. Corrections and Wind Speed
- Corrections are like tracking a VOR
  - a Once the correction is made (or an intercept angle is established), remove the correction when the pylon is back on the line-of-sight reference (or "intercepting the radial")
    1. Don't make the correction and hold it
       a. That will result in going above/below the pivotal altitude
- Changes in pitch/altitude are based on wind speed
  - a The greater the wind speed, the greater the variation in the max/min pivotal altitudes
- Too strong of winds becomes unsafe
  - a We get closer and closer to the ground
  - b Also, the airplane can be blown very close to the pylon, requiring very high bank angles

d. RM: Uncoordinated flight AI.IX.F.R5
- This is the most common error in eights on pylons
- Do not use the rudder to yaw the wing forward or backward to maintain the line-of-sight reference
- Use altitude changes to hold the reference point on the pylon
- Cross controlled flight is dangerous, especially close to the ground

ii. Bank

a. Performed at bank angles ranging from shallow to steep (no more than 40º per the ACS)
- The bank chosen does not alter the pivotal altitude

b. Distance from the pylon affects bank
- As wind pushes the aircraft toward or away from the pylons, bank will have to be adjusted to maintain the reference line

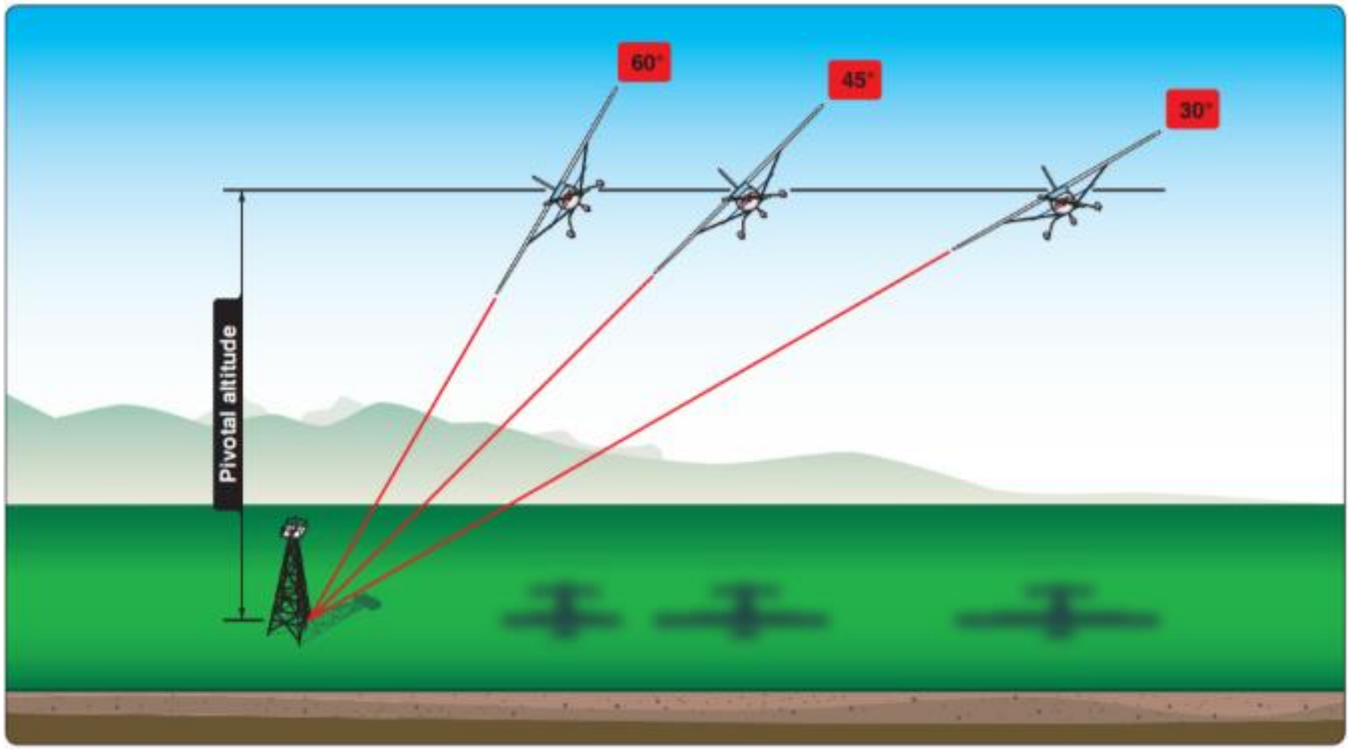
c. If the pylon moves above your reference point (i.e. above the wing tip), the aircraft is banked too steep, should be decreased to maintain the reference

d. If the pylon moves below your reference point (i.e. below the wing tip), the bank is too shallow, and bank should be increased to maintain the reference

e. Note: Per the Airplane Flying Handbook, as proficiency is gained, the instructor should increase the complexity of the maneuver by directing the student to enter at a distance from the pylon that requires a specific bank angle at the steepest point in the pylon turn

iii. RM: Energy Management & Power AI.IX.F.R6

a. Pivotal altitude is based on groundspeed
- Properly set power prior to entering the maneuver to keep the desired indicated airspeed consistent
- Changes in power lead to changes in airspeed
  - a Changes in airspeed will adjust the pivotal altitude and lead to changes in pitch
- The more consistent the power setting, the more consistent the airspeed
  - a This leads to a smoother maneuver that requires less work from the pilot



3. Calculating Pivotal Altitude

AI.IX.F.K3

A. Equation to estimate pivotal altitude
   i. For Knots – $(Groundspeed^2 \div 11.3)$ + MSL
   ii. For MPH – $(Groundspeed^2 \div 15)$ + MSL
B. Never going to be exact – use the planned true airspeed and estimated winds at altitude
C. Calculate the highest pivotal altitude: TAS + tailwind (highest groundspeed)
   i. Use a flight computer
      a. Take into account wind direction, speed, and true airspeed to get groundspeed
D. Calculate the lowest pivotal altitude: TAS – headwind (lowest groundspeed)
   i. Remember that when in a headwind, we will be descending
      a. Groundspeed will be slightly faster than planned and if the wind estimates are correct, we won't get as low as expected
E. Calculating the highest and lowest pivotal altitude will provide an expected altitude window
   i. If the altitudes are not safe, do not perform the maneuver

Groundspeed		Approximate Pivotal Altitude
Knots	MPH	
87	100	670
91	105	735
96	110	810
100	115	885
104	120	960
109	125	1050
113	130	1130

4. Performing Eights on Pylons

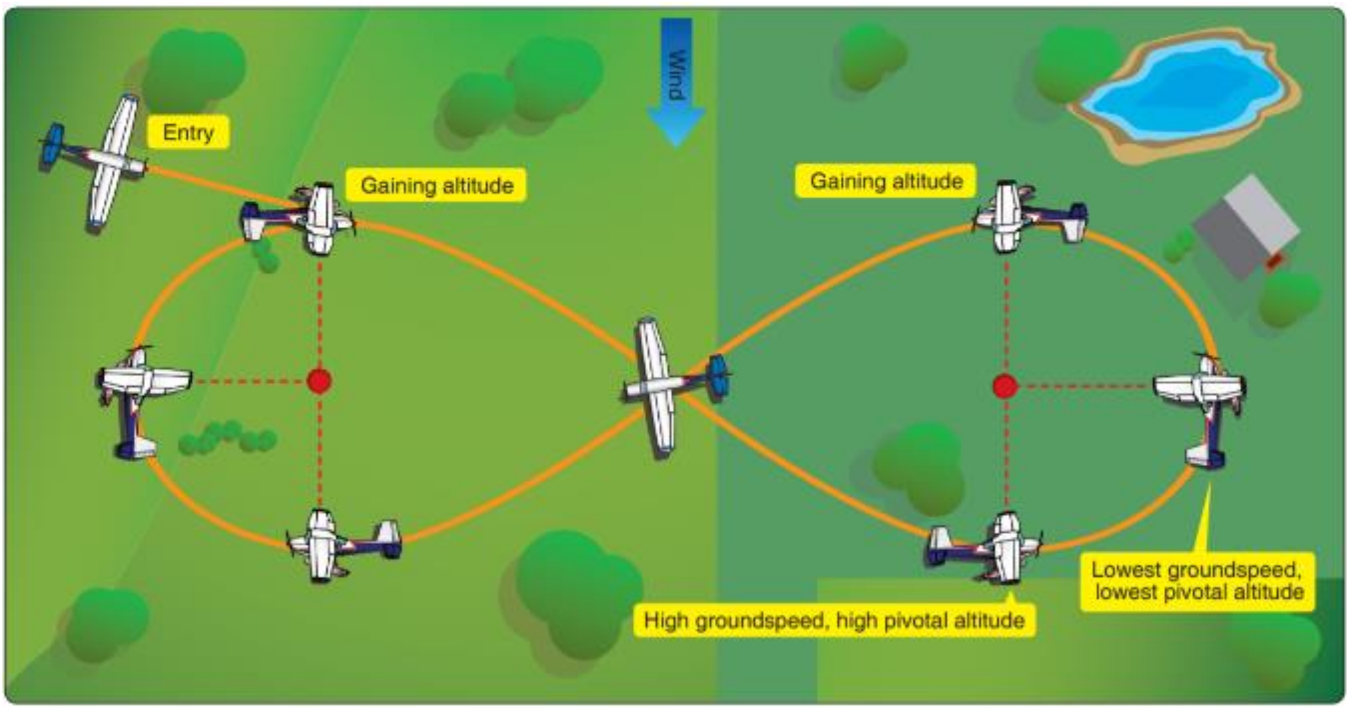
AI.IX.F.K1, AI.IX.F.K5

A. Selecting the Pylons
   i. Select two points on the ground along a line which lies perpendicular to the wind
   ii. The pylons should be:
      a. Sufficiently prominent so the pilot can view them when completing the turn around one pylon and heading for the next
      b. Adequately spaced to provide time for planning the turns but not spaced so far apart that they cause unnecessary straight-and-level flight between the pylons

- The distance between the pylons should allow the straight-and-level segment to last 3-5 seconds
- About ½ mile apart is a good estimate
    - a The length of a small runway

c. At the same elevation, since differences over a few feet require climbing or descending between turns
d. In an open area and are not near hills or obstructions
e. The smaller the pylon, the easier to notice changes in movement (as long as you can see it)

iii. RM: Emergency Landing Considerations AI.IX.F.R7
   a. Performed at low altitudes
   b. There will be very little time and distance to glide to an emergency landing area
      - Select reference points in an area that provides for an emergency landing
   c. Know what you will do and where you will go in the case of an emergency



B. Before the Maneuver
   i. Pre-maneuver checklist
   ii. Ensure the area is clear of traffic
      a. Below, at, and above your altitude
   iii. The airplane should be trimmed for straight and level flight, at or below V_A

C. Entering the Maneuver
   i. Enter at a 45° angle to the downwind to make the first turn to the left around the left pylon
      a. The left turn puts the pylon out the left window (easiest to see), rather than looking over the right seat passenger and through the right window
      b. Make note of the entry heading as it will be the exit heading as well (bug the heading)
   ii. Fly to the midpoint between the pylons
   iii. A downwind entry starts with the highest groundspeed and therefore the highest pivotal altitude
   iv. Fly straight-and-level until the pylon is just ahead of the reference line, then roll into a 30°-40° bank
      a. Not to exceed 40°
   v. Place the wingtip at the base of the pylon

D. First Turn
   i. Entry is at the highest groundspeed

a. Continuing through the turn, into an increasing headwind, groundspeed will get progressively slower
   - Pivotal altitude will decrease
     a If no corrections are made, the pylon will move forward of the wing tip
        1. Forward movement = forward pressure

b. Descend to maintain correct pivotal altitude/reference point
   - Do not wait for the pylon to get significantly out of position, make consistent small corrections
   - Any airspeed gained in the descent increases pivotal altitude and helps correct the visual reference

ii. Continuing the turn

a. Continuing the turn, groundspeed will begin to increase, and therefore pivotal altitude will increase
   - Climb to maintain pivotal altitude and the visual reference
     a If no corrections are made the pylon will move backward in relation to the wingtip
        1. Backward movement = back pressure
     b Any airspeed lost in the climb decreases pivotal altitude and helps correct the visual reference

b. The relative wind will push the airplane towards the pylon AI.IX.F.K4
   - Bank angle will increase to maintain the visual reference
     a Remember, bank angle has no effect on pivotal altitude
     b No drift correction required since there’s no requirement to maintain a constant radius
     c Stay coordinated

E. Transitioning between Pylons

i. As the airplane turns toward a downwind heading, the rollout of the turn should be started
   a. The airplane should proceed diagonally to a point on the downwind side of the 2nd pylon

ii. Maintain straight and level flight for 3 to 5 seconds

iii. Crab into the wind to correct for wind drift AI.IX.F.K4
   a. The nose of the aircraft will have to point into the wind to properly correct for drift
      - The stronger the wind, the greater the correction required

iv. Initiate a turn in the opposite direction when the pylon is aligned with the wing reference point

F. Second Turn

i. Entry is once again at the highest groundspeed, and therefore the highest pivotal altitude
   a. As the turn continues, groundspeed decreases as the aircraft experiences more of a headwind
      - Pivotal altitude decreases
        a Descend to correct for changing groundspeed
        b The pylon will begin moving in front of the wingtip
           1. Forward movement = forward pressure

ii. Continuing the turn, the headwind will transition into more of a tailwind, and an increasing groundspeed
   a. Increasing groundspeed = Increasing pivotal altitude
   b. The pylon will move backward in relation to the wingtip
      - Backward movement = back pressure (climb)
        a Any airspeed lost in the climb reduces groundspeed and lowers the pivotal altitude
   c. At this point, relative wind also pushes the airplane closer to the pylon AI.IX.F.K4
      - Bank must increase to maintain visual reference

G. Exit

i. After completing one rotation around each pylon, roll wings level, and exit on the entry heading

5. Common Errors AI.IX.E.K5

A. Failure to adequately clear the surrounding area for safety hazards, initially and throughout the maneuver.

B. Failure to establish a constant, level altitude prior to entering the maneuver.

C. Failure to maintain altitude during the maneuver.

D. Failure to properly assess wind direction.

E. Failure to properly execute constant radius turns.
F. Failure to manipulate the flight controls in a smooth and continuous manner.
G. Failure to establish the appropriate wind correction angle.
H. Failure to apply coordinated aileron and rudder pressure, resulting in slips or skids.

6. Hazards

A. Division of Attention AI.IX.F.R1
  i. The entire maneuver is based on planning ahead (pivotal altitude), orienting yourself in relation to the wind and dividing attention between the aircraft, the reference points and what is coming next
    a. Solid planning, starting with the pivotal altitude calculations on the ground, wind direction and reference point selection in the air, and smooth, proactive control inputs during the maneuver will make the eights on pylons much easier to perform
    b. Poor planning results in a sloppy, considerably more difficult maneuver
  ii. Crosscheck should focus primarily on outside references with glances inside for airspeed, altitude, etc.
    a. Over concentration inside or outside will result in the other being neglected and a poor maneuver
    b. Allows the pilot to divide attention between aircraft control and the orientation
      - Orientation does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (aircraft, airports, etc.)
  iii. In the case of an unsafe situation or orientation stop the maneuver and fix the problem. Safety first

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. IX. RM Concepts - Distractions, SA & Disorientation, Task Prioritization AI.IX.F.R4
B. IX. RM Concepts - Low Altitude Maneuvering AI.IX.F.R3
C. IX. RM Concepts - Collision Hazards AI.IX.F.R2

Conclusion:
Brief review of the main points
If the point moves forward, apply forward pressure. If the point moves backward, apply back pressure.
Eights on Pylons is the most advanced and most difficult of the low altitude flight training maneuvers. Because of the various techniques involved, this maneuver is unsurpassed for teaching, developing, and testing subconscious control of the airplane.

Commercial Pilot ACS Skills Standards

1. Establish the correct bank angle for the conditions, not to exceed 40°.

IX. RM Concepts

1. **Distractions, SA & Disorientation, & Task Management**
   - A. Distractions
     - i. They're dangerous
       - a. Can lead to slow speeds, unintended aircraft attitudes, collisions, disorientation, missed radio calls, etc.
       - b. Remove distractions from your field of view or, in the case of a person, explain the situation and ask them to stop what they are doing
     - ii. Sterile flight deck
       - a. Implement and maintain a sterile flight deck during taxi, takeoff, and climb as well as descent and landing
     - iii. Fly first! Aviate, Navigate, Communicate
       - a. Focus on the tasks at hand and stay ahead of the aircraft
       - b. Ensure checklists have been completed, and both you and the aircraft are prepared for what's next
   - B. Situational awareness (SA) & Disorientation
     - i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
     - ii. Maintain SA
       - a. Starts with preflight planning
       - b. Know what's coming next and stay ahead of the airplane
       - c. Be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
       - d. Divide attention between inside and outside references
       - e. If SA is lost, admit it
         - If there's another pilot, let them take over while you catch up, if not, get the aircraft in a safe position (if landing, go around; if disoriented, trust the instruments and get to a safe attitude/altitude) and then solve the problem
     - iii. Disorientation can be caused by, or lead to, an upset
       - a. Push: Apply forward pressure to unload the plane
       - b. Roll: Roll aggressively to the nearest horizon
       - c. Thrust: Adjust as required
       - d. Stabilize: Return to a safe flight condition
   - C. Task Management
     - i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
       - a. No one responsibility should take your full attention full more than a short period
     - ii. Understand what tasks need to be accomplished and when
       - a. Prioritize based on importance and time available
       - b. Checklists and standard operating procedures are extremely helpful and enhance safety
     - iii. Recognize when you are getting behind and find a way to catch up
       - a. If more time is needed, find somewhere to hold/circle, or slow down
       - b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
       - c. "Attack the closest alligator" – Deal with the most pressing problem
     - iv. Proper task management can help prevent distractions, loss of SA, and disorientation
     - v. Safety is the number one priority – Aviate, Navigate, Communicate
2. **Collision Hazards**
   - A. Collision Avoidance
     - i. Scanning
       - a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
         - Each movement should not exceed 10°, each area should be observed for at least one second

b. Divide attention between flying and scanning for aircraft
   - Applicable in all phases of flight, especially important in high traffic areas

ii. Clearing Procedures
   a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
   b. Prior to any turn: Clear in the direction of the turn
   c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind

iii. Operation Lights On
   a. Voluntary FAA safety program to enhance the see and avoid concept
   b. Turn on landing lights during takeoff and when operating below 10,000', day or night
      - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected

iv. Right-of-Way Rules (FAR 91.113)
   a. An aircraft in distress has the right-of-way over all other traffic
   b. Converging Aircraft
      - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
      - If the aircraft are different categories:
         a Basically, the less maneuverable aircraft has the right-of-way
            1. Balloons, gliders, and airships have the right of way over airplanes
         b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
   c. Approaching Head-on: Each pilot shall alter course to the right
   d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
   e. Landing
      - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
         a Do not take advantage of this rule to force an aircraft off the runway which has already landed
      - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
         a Don't take advantage of this rule to cut in front of another aircraft

B. Terrain
   i. Plan well and be aware of terrain that could cause a hazard
      a. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
   ii. Day vs Night flying over terrain
      a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
      b. A personal minimum may be to only fly over high terrain during daylight
   iii. Minimum Safe Altitudes (FAR 91.119)
      a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
      b. Over Congested Areas: 1,000' above the highest obstacle within 2,000'
      c. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

C. Obstacles and Wire Strike
   i. Antenna Towers
      a. Numerous antennas extend over 1,000'-2,000' AGL
         - Most are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as guy wires can extend 1,500' horizontally from a structure
   ii. Overhead Wires (may not be lighted)
      a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
         - Lakes, highways, railroad tracks, etc.

3. Low Altitude Maneuvering

A. A small problem at high altitude can quickly become a big problem at a low altitude
   i. There is considerably less time to handle any issues at a low altitude

    ii. Avoid distractions, maintain situational awareness, and fly precisely
B. Be aware of, and avoid obstructions on and around the airfield
    i. Quick, panicked maneuvers, especially when slow, can result in a stall or loss of control close to the ground
C. Low Altitude Stall/Spin
    i. A low altitude stall or spin can leave little to no recovery time
        a. ALWAYS maintain coordination, and airspeed at low altitudes
        b. Keep airspeed in your crosscheck, especially at the lower speeds associated with takeoff and landing
        c. If you get any indication of a stall at low level, recover, and climb to a safe altitude
        d. Steep Turns: Accelerated stall is likely the biggest threat
        e. Steep Spiral: Power-off stall is likely the biggest threat
        f. Chandelles: Power-off or accelerated stalls are likely the biggest threat
        g. Lazy Eights: Power-off or accelerated stalls are likely the biggest threat
    ii. Spin
        a. A spin is a result of a stall + yaw
        b. Prevention
            - Maintain coordination & do not use abrupt, excessive pressure inputs (especially back pressure)
            - Stop whatever you're doing and recover at the first sign of a stall
        c. Recovery (PARE)
            - Power - Idle
            - Ailerons - Neutral
            - Rudder - Full rudder opposite the spin direction
            - Elevator - Brisk, positive forward pressure (nose down)
            - Once the spin has stopped, neutralize the rudders, and raise the nose - be careful not to stall again
        d. Different aircraft respond differently to spins and spin recoveries, follow the POH procedures
D. CFIT (Controlled Flight into Terrain)
    i. AC 61-134: General Aviation CFIT Awareness
    ii. The solution to combating CFIT accidents starts on the ground
        a. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
        b. How the flight is planned and handled largely determines the safety of the flight
    iii. Recommendations:
        a. Non-instrument rated VFR pilots should not attempt to fly in IMC
        b. Know and fly above minimum published safe altitudes
        c. If IFR, fly published procedures
        d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter
        e. Verify all ATC clearances. Question potentially hazardous clearances
        f. Maintain situational awareness both vertically and horizontally
        g. Comply with appropriate regulations for your specific operation
        h. Don't operate below minimum safe altitudes if uncertain of position or ATC clearance
        i. Be extra careful when operating in an area which you are not familiar
        j. Use current charts and all available information
        k. Use appropriate checklists
        l. Know your aircraft and its equipment

SLOW FLIGHT, STALLS & SPINS

X.A. Maneuvering During Slow Flight

References: Airplane Flying Handbook, Pilot's Handbook of Aeronautical Knowledge, POH/AFM

Objectives	To develop an understanding and proficiency of the flight characteristics and controllability of an aircraft in slow flight. A "feel" for the airplane at low speeds should be developed to avoid inadvertent stalls and to operate with precision. The learner should perform to ACS standards.
Key Elements	1. Pitch for Airspeed 2. Power for Altitude 3. Stay Coordinated

Elements	1. What is Slow Flight
	2. Slow Flight Aerodynamics
	    a. Airspeed
	    b. Power & the Region of Reversed Command
	    c. Yaw Effects
	    d. Maneuvering Loads & Turns
	    e. Weight
	    f. Center of Gravity
	    g. Environmental Elements
	3. Critical Flight Situations
	4. Slow Flight and the Senses
	5. Performing Slow Flight
	6. Common Errors
	7. Hazards

Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands factors affecting flight characteristics and controllability and shows the ability to control the airplane effectively in different slow flight configurations.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

When the aircraft is flying at just above the stall speed, there is little margin for error. This maneuver will greatly improve your piloting skills.

Overview

Review Objectives and Elements/Key ideas

What

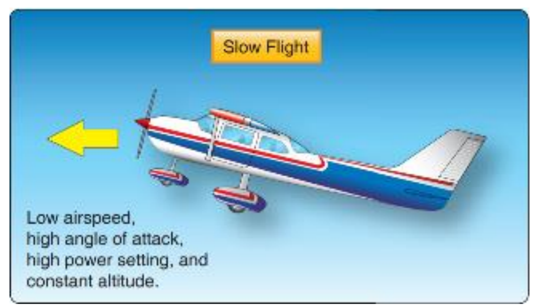
Slow flight is flight at a speed at which any further increase in angle of attack or load factor, or reduction in power will result in a stall warning.

Why AI.X.A.K1

The aircraft performs and is controlled differently at slower airspeeds. Maneuvering during slow flight demonstrates the flight characteristics and degree of controllability of an aircraft near the critical AOA. In normal operations, the aircraft would not be flown this close to the critical AOA, but because the aircraft is flown at higher angles of attack and slower airspeeds in many phases of flight (takeoff, landing, go-around), understanding how the aircraft performs and is controlled at reduced speeds is essential, especially in the case the aircraft ends up slower than intended.

How:

1. **What is Slow Flight**

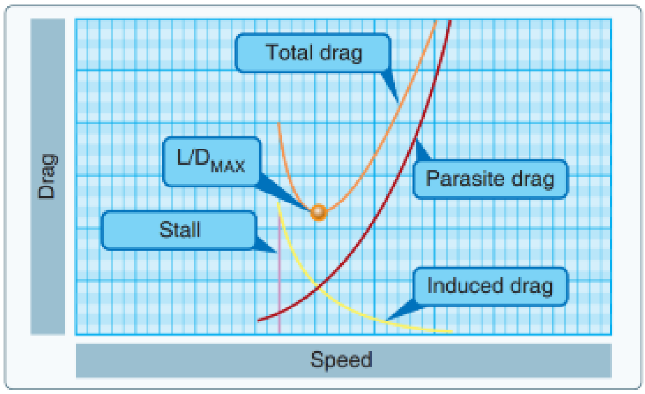


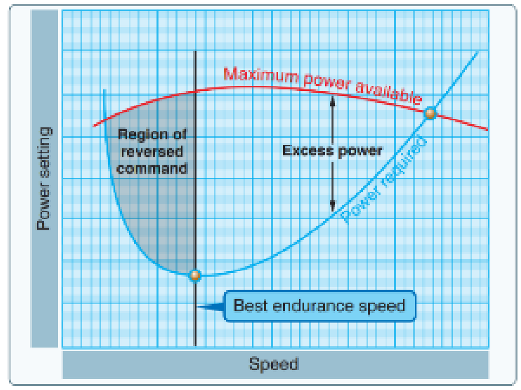
   A. Technically, any speed less than cruise speed, however, in pilot training, it can be broken into two elements
      i. The establishment, maintenance of, and maneuvering of the aircraft at airspeeds and in configurations appropriate to takeoffs, climbs, descents, landing approaches and go-arounds
         a. i.e., phases of flight other than cruise
         b. This description is most applicable to every day flying
      ii. Flight at a speed which any further increase in AOA or load factor, or reduction in power will result in a stall warning
         a. This description is used for the slow flight maneuver
         b. Objective is to understand the flight characteristics and how the flight controls feel near the critical AOA
2. **Slow Flight Aerodynamics** AI.X.A.K2
   A. **Airspeed**
      i. An increase or decrease in airspeed increases or decreases lift, affecting AOA and attitude
         a. As airspeed decreases, AOA must be increased to maintain lift and altitude (and vice versa)
      ii. In relation to slow flight, the slower the airspeed, the higher the AOA required
         a. Closer to the critical AOA
   B. **Power & the Region of Reversed Command**
      i. Normal Command
         a. As airspeed decreases, total drag decreases, until reaching a point (L/D_{MAX})
            - This is the normal region of command – while maintaining an altitude, higher speeds require higher power settings, and lower speeds require lower power settings
      ii. Region of Reversed Command

a. As airspeed decreases below L/D_{MAX}, total drag begins to increase
- This is referred to as the region of reversed command

iii. Below L/D_{MAX}, while maintaining altitude, slower airspeeds require higher power settings and faster airspeeds require lower power

iv. Thus, when in the region of reversed command, the slower the airspeed, the more power required

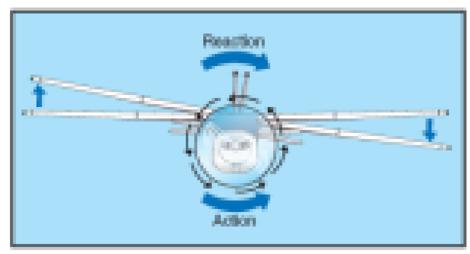




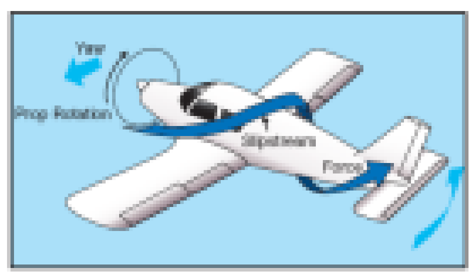
C. **Yaw Effects**

i. Increased power at slow airspeeds and high angles of attack results in increased left turning tendencies
   a. Anticipate considerable right rudder to maintain coordination

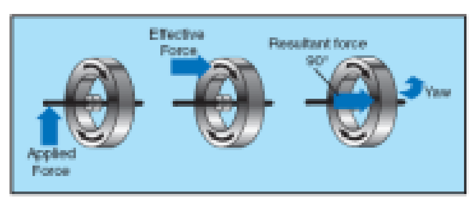
ii. Torque Reaction
   a. Newton's 3rd Law – Every action has an equal/opposite reaction
      - The engine/propeller rotate one way; an equal force tries to rotate the plane the opposite direction
   b. Although torque reaction is more of a rolling tendency than a yaw effect, it does contribute to the left turning tendencies



iii. Corkscrew/Slipstream Effect
   a. The high-speed rotation of the propeller sends air in a corkscrew rotation to the rear of the aircraft
      - Air strikes the left side of the vertical stabilizer, pushing the nose of aircraft left
   b. At high propeller speeds/low forward speeds (like in slow flight) the rotation is compact & pronounced
      - Exerts a strong sideward force on the vertical tail causing yaw to the left
      - As forward speed increases, the spiral elongates and becomes less effective
   c. Countered with coordinate rudder and aileron

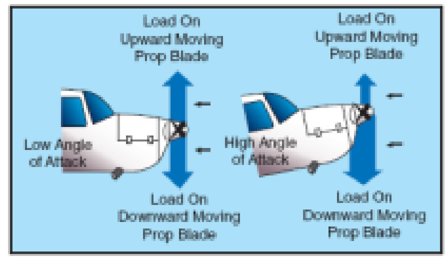


iv. Gyroscopic Action
   a. Gyroscopes are based on two fundamental principles:
      - Rigidity in space (not applicable to this discussion)
      - Precession - The resultant action of a spinning rotor when a force is applied to its rim
         a If a force is applied, it takes effect 90° ahead of, and in the direction of turn
            1. This causes a pitch/yaw moment or combo of the two depending on where applied
      - Any yawing around the vertical axis results in a pitching moment
      - Any pitching around the lateral axis results in a yawing moment
   b. In relation to slow flight, lifting the nose results in a yaw to the left



- Correction is made with elevator and rudder pressures to maintain pitch attitude & coordination

v. Asymmetric Loading (P Factor)



  a. When flying at a high AOA, the bite of the down moving blade is greater than the up moving blade
    - Moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)

  b. In relation to slow flight, the high angle of attack associated with slow flight results in an increase in p-factor which needs to be compensated for with right rudder

vi. Big Picture

  a. Considerable right rudder is required to maintain coordination during slow flight

  b. When introducing turns:
    - A right turn requires even more right rudder
    - A left turn requires less right rudder (still requires right rudder)

D. **Maneuvering Loads & Turns**

i. Load factor: Ratio of the total load acting on the aircraft to the gross weight of the aircraft

  a. Expressed in terms of Gs

ii. Any increase in load factor increases stall speed

iii. Turns

  a. Increased load factors are a characteristic of all turns

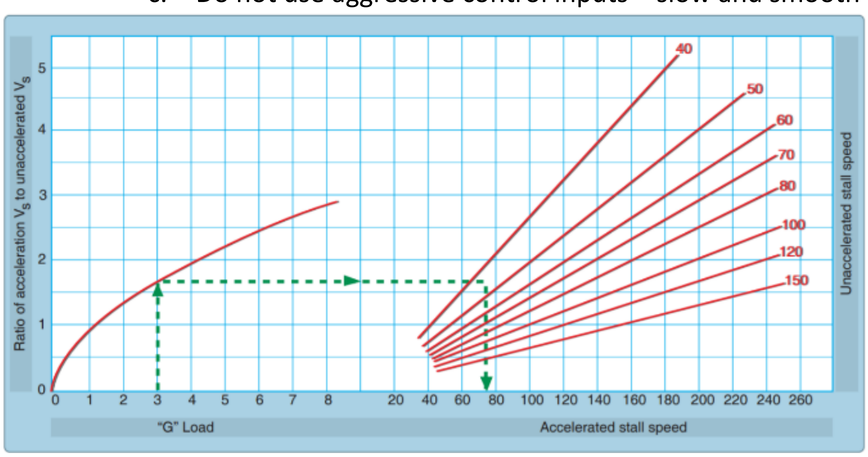
  b. Load factor increases at a high rate after 45º-50º of bank
    - At approx. 63º of bank the stall speed is increased by approximately ½

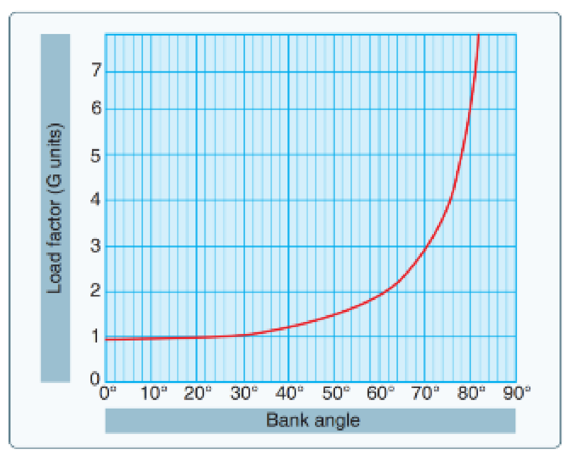
iv. Slow Flight & Controllability

  a. In slow flight the airplane is already very close to the stall speed

  b. The increased load factor associated with a turn in slow flight can quickly put the aircraft into a stall
    - Use gentle, coordinated, low bank turns during slow flight to prevent a potential stall
      a 10º of bank is generally a good target (depending on the aircraft)

  c. Do not use aggressive control inputs – slow and smooth





E. **Weight**

i. The heavier an aircraft, the more lift required to maintain altitude

  a. As more lift is required, the AOA required to maintain level flight is increased
    - An increased AOA brings the aircraft closer to the critical AOA, and therefore the stall speed will be reached sooner (at a higher airspeed) than if the aircraft were lighter

ii. A heavier aircraft is more stable than a lighter aircraft

  a. Generally, though, the position of the center of gravity has more effect on the stability (more below)

b. It takes more force to move a heavier object than a lighter one

iii. Slow Flight & Weight

a. Because a heavier aircraft is at a higher AOA for a given airspeed, less pitch change is required to reach the critical AOA

b. The increased weight and stability may help in controlling the aircraft

F. **Center of Gravity**

i. Forward Loaded Aircraft

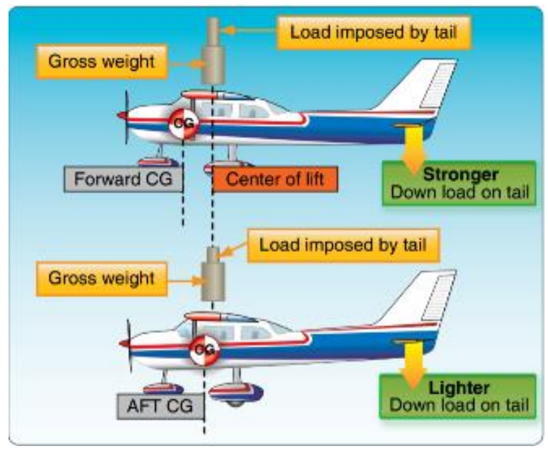
a. The aircraft acts heavier, and consequently slower (for a given power setting) than the same aircraft with a further aft center of gravity

- More nose up elevator pressure and/or trim is required to maintain altitude
- The higher nose requires the tail surface to produce a greater down load
- The increased down load adds to wing loading, increasing total lift required to maintain altitude

b. The higher AOA results in more induced drag and a higher stall speed (like a heavy aircraft)

c. Controllability

- A forward loaded aircraft is more controllable than an aft loaded aircraft
  - a Due to the longer arm from the elevator to the center of gravity
  - b Weight x Arm = Moment. Longer arm = greater moment and thus a more controllable aircraft



ii. Aft Loaded Aircraft

a. The aircraft acts lighter, and consequently faster (for a given power setting) than the same aircraft with a further forward CG

- Less nose up elevator pressure/trim is required to maintain altitude
- The lower nose requires less of a down load from the tail
- The decreased down load reduces wing loading and decreases total lift required to maintain altitude

b. The lower AOA results in less induced drag allowing for faster cruise speed and a lower stall speed

c. Controllability

- Recovery from a stall becomes progressively more difficult as the center of gravity moves aft
  - a Moving the CG aft shortens the arm, reducing the amount of force it can apply
  - b Weight X Arm = Moment. Shorter the arm = smaller moment and therefore less controllable

3. Critical Flight Situations

A. It is very important to understand the control responses of the aircraft at slow flight speeds and the region of reversed command, especially since the majority this time is spent close to the ground

i. In general, takeoffs, climbs, landings, and go-arounds

B. RM: Inadvertent slow flight (distractions, disorientation, microburst, etc.) AI.X.A.R1

i. If unexpectedly in a slow flight or stall airspeed situation, proper control & recovery is imperative

ii. A lack of understanding and/or ability could rapidly lead to a loss of control

a. Especially dangerous if close to the ground

C. Critical Flight Situation Examples (Pilot's Handbook of Aeronautical Knowledge):

i. Low speed, high pitch approach to a short-field landing

a. Region of reversed command

b. If an excessive sink develops, it may be possible to reduce/stop the descent with power. But without further use of power, the plane would probably stall or be incapable of flaring for the landing

c. Lowering the nose, without power, would result in a rapid sink rate and loss of altitude

- ii. Soft-field takeoff and climb
  - a. Attempting to climb out of ground effect without attaining normal climb pitch and airspeed, may result in inadvertently entering the region of reversed command at low altitude
  - b. Even with full power, the plane may be incapable of climbing or even maintaining altitude. The only option is to lower pitch to increase airspeed, which inevitably results in a loss of altitude
- iii. A stall with high power and close to the ground may not provide time to recover
  - a. A stall with excessive yaw (high pitch & power) could lead to a spin & a loss of control

D. Give particular attention to precise airspeed control at low flight speeds in the region of reversed command

4. Slow Flight and the Senses

A. Visually
- i. As you pitch up, you will be looking at more sky (nose above the horizon)
  - a. There will be few if any visual references at this point
    - Possibly a couple of clouds
- ii. Hearing
  - a. Initially it will get quieter with the reduction of power and airspeed
  - b. As you approach the stall, the stall warning horn sounds
  - c. When power is reintroduced, the sound of the engine increases
    - The sound of the plane moving through the air stays softer due to the slow airspeed
- iii. Feel
  - a. As the aircraft's speed continues to decrease, the controls will become progressively less responsive
    - Larger movements will be necessary as the air flow over the control surfaces is reduced
  - b. Right rudder will be necessary to maintain coordination as the aircraft begins to yaw to the left
    - This is due to the left turning tendencies upon reintroduction of power
    - Due to reduced control effectiveness, more right rudder than normal is required
  - c. Just prior to stalling the aircraft will begin to buffet
- iv. RM: Stall Warning Range & Limitations AI.X.A.R2
  - a. Buffet: Tends to occur prior to the stall horn
    - Generally, an early indication of a stall
    - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
      - a Design, attitude, configuration, etc. preventing turbulent air from the wings hitting the stab
  - b. Stall Horn
    - Designed to provide warning of an approaching stall and time for stall recovery
    - Per 23.207
      - a Clear/distinct stall warning with flaps & gear in any normal position, in straight and turning flight
      - b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
      - c Must provide the pilot time to take action to avert the stall
  - c. Stall indications and horns have different operational ranges and limitations
    - Reference the POH for specific information
    - Ex: Uncoordinated flight may inhibit airflow at the stall indicator
      - a Situations where one wing (without the indicator) stalls first

5. Performing Slow Flight AI.X.A.K1, AI.X.A.R1

A. Purpose
- i. Demonstrate the flight characteristics and controllability of the airplane at its minimum flying speed
- ii. RM: Provide the pilot the tools to recognize & recover from inadvertent slow flight preventing loss of control

B. Performing the Maneuver
- i. Overview of the Basics
  - a. Pitch for Airspeed, Power for Altitude

- This is necessary on the backside of the power curve

b. Use both instrument indications and visual references
  - Frequently reference the instruments, especially the attitude indicator
  - A "feel" for the airplane at very low speeds must be developed to avoid inadvertent stalls and to operate the plane with precision

ii. The Maneuver

a. Properly clear the area

b. Pre-maneuver checklist

c. Select an altitude
  - No lower than 1,500' AGL
  - Select an altitude that is easy to read on the altimeter
  - 500' increments are easiest

d. Configuration
  - Different configurations can be used to develop a feel for the airplane in different situations
    - a The 'dirtier' (more flaps), the slower we can get
      1. Stall speed is reduced
    - b A 'cleaner' plane has a higher stall speed, therefore a higher airspeed is required for slow flight

e. *Begin slowing by gently reducing the throttle (to approximately 1500 RPM)
  - Maintain altitude as power is lost
    - a Use visual references backed up by the instruments to reference the pitch attitude at the start of the maneuver. Gently increase pitch attitude as airspeed slows to maintain altitude
      1. Too little pitch results in a loss of altitude and could lead to stagnant/increasing airspeed
      2. Excessive pitch will result in a climb followed by a rapid decrease in airspeed

f. Continually trim the aircraft
  - Add nose up trim to maintain altitude, this will make the maneuver considerably easier
  - Re-trim as often as necessary to compensate for changing control pressure

g. Full flaps should be lowered as the airspeed reaches the flap airspeed limits
  - Lowering the flaps one at a time allows the pilot to adjust the pitch for the changing lift and maintain better control
    - a Extending full flaps immediately is more difficult to control than incremental changes
    - b Anticipate changes in lift as flaps are extended or retracted
      1. Lowering the flaps will require nose down pitch to compensate for increased lift

h. Note the feel/sounds
  - As airspeed decreases, the pilot should note the feel of the flight controls (especially elevator)
  - Also note the sound of the airflow as it gets quieter

i. Flight Control Effectiveness
  - Flight controls are much less effective with the reduction in airspeed
    - a Elevators become less responsive
    - b Flight control inputs are not as smooth to control the airplane
      1. Larger movements are needed for the aircraft to respond

j. Reintroduce power
  - Additional power will be required as airspeed decreases below L/D_{MAX} to maintain altitude
    - a *As the airspeed is approaching the specified maneuver speed (approximately 40 knots) introduce power to maintain altitude, and airspeed just above the stall
    - b Be familiar with the approximate pitch and power settings for your aircraft
      1. When approaching the desired speed, set that pitch and power, and adjust from there
  - The additional power produces a strong left yaw

- a Considerable right rudder is necessary to maintain coordinated flight
- b RM: Uncoordinated flight & Improper correction for torque effect AI.X.A.R3
  1. Anticipate the need for right rudder
     a. Anticipate the need for power to allow for a slow, smooth throttle increase
     b. As power comes up slow and smooth, increase right rudder to maintain coordination
        i. An outside reference works great – maintain wings level, and as power is introduced add right rudder. If the aircraft swings right, reduce the rudder input. If the aircraft swings left, increase the right rudder input
  2. Use coordinated rudder and aileron to maintain heading
     a. Uncoordinated flight (too much or too little rudder to compensate for torque) combined with a stall can quickly result in a spin

- Avoid losing too much speed/using too little power
  - a Proactively increase power to the approximate setting to maintain altitude

k. Establish the desired pitch attitude to maintain airspeed
- Cross check the instruments (attitude indicator, heading indicator, airspeed, turn coordinator), as well as outside references to ensure precise control of the aircraft
  - a If fast, pitch up – use very small changes in pitch (1-2^{o} at a time)
  - b If slow, pitch down – again, very small changes in pitch (1-2^{o} at a time)
  - c Generally, a change in pitch requires a corresponding change in power
- Do not fixate on any instruments, primarily the airspeed indicator and altimeter
- Throughout the maneuver, be proactive in fixing altitude, heading, airspeed
  - a Use small, controlled changes in pitch and power to maintain heading and altitude
    1. Know the approximate pitch and power setting required to maintain slow flight in the aircraft; set that pitch and power and make small adjustments from there
    2. Set and maintain the rudder pressure required to maintain coordination

l. Maintain straight and level flight and perform the required level turns at a constant altitude
- Introducing Bank
  - a Use smooth, controlled control inputs
    1. Aggressive inputs can lead to increased load factors, and deviations in heading/altitude
    2. The Airplane Flying Handbook discusses practicing medium banked (20^{o}) turns
  - b Adjust pitch and power as needed to maintain altitude and airspeed
    1. Generally, additional power will be necessary. Increased power likely leads to increased pitch to maintain airspeed – anticipate these inputs
       a. A turn and change in power require a change in rudder to maintain coordination
- Maintaining the Bank Angle
  - a In slow flight, even a small amount of bank results in an overbanking tendency
    1. Opposite aileron is necessary to maintain the bank angle
- RM: Adverse Yaw in the Turn (RM: Uncoordinated flight)
  - a The downward deflected aileron produces more lift and therefore more drag
  - b The airplane will try to yaw toward the outside wing during the turn
    1. Maintain coordination
    2. Right rudder is necessary for straight flight
       a. Right turns will require more right rudder
       b. Left turns will require less right rudder (anticipate some right rudder even in a left turn)
- Extreme Bank
  - a Extreme bank situations, like steep turns, are not used in slow flight
    1. As banks exceeds 30^{o}, the stall speed noticeably increases

- a. Obviously, this is unsafe when already close to the stall speed
- m. Maintain coordinated flight as climbs/descents or climbing/descending turns are performed
  - Adjust power to begin the climb or descent, and simultaneously adjust pitch to maintain airspeed
    - a Pitch for airspeed, Power for altitude
      1. You will gain altitude by increasing power, and lose altitude by decreasing power
         a. Adjust pitch to maintain airspeed
         b. Anticipate increased right rudder with an increase in power, and vice versa

iii. Reestablishment of cruise flight
- a. Very similar to a stall recovery:
  - Full Power
    - a Smoothly increase the power
  - Nose Down (forward pressure)
    - a Smooth, controlled forward pressure to maintain the current altitude
      1. Don't dive
    - b Retrim the aircraft as it accelerates to avoid excessive control pressures
      1. If the nose was trimmed up, the aircraft will try to fly up as it accelerates
    - c As airspeed increases, right rudder pressure is reduced to maintain coordination
  - Cleanup
    - a Flaps
      1. Remove the flaps in stages, based on airspeed requirements
      2. Anticipate the change in lift as the flaps are retracted and maintain altitude
         a. The aircraft will tend to sink, increase back pressure to counter this
    - b Gear (If necessary) – Generally, retract flaps, gear, flaps
  - Establish straight and level flight at V_A, or the desired speed
    - a Set the power for the desired speed
    - b Finalize the trim

C. Unintentional Stall Considerations
- i. Avoid being aggressive with the power and pitch applications
  - a. Small, controlled corrections are most effective in maintaining control during slow flight
  - b. Anticipate the power introduction to allow for a slow, smooth power push
- ii. Always keep one hand on the throttle (within reason)
  - a. Due to the proximity to a stall, immediate power may be necessary

6. Common Errors AI.X.A.K3

A. Failure to adequately clear the area
B. Inadequate back-elevator pressure as power is reduced, resulting in altitude loss
C. Excessive back-elevator pressure as power is reduced, resulting in a climb followed by rapid reduction in speed
D. Insufficient right rudder to compensate for left yaw
E. Fixation on the flight instruments
F. Failure to anticipate changes in AOA as flaps are extended or retracted
G. Inadequate power managements
H. Inability to adequately divide attention between airplane control & orientation
I. Failure to properly trim the airplane
J. Failure to respond to a stall warning

7. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. X. RM Concepts – Environmental Elements AI.X.A.R4
B. X. RM Concepts – Collision Hazards AI.X.A.R5

C. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.A.R6

Conclusion:
Brief review of the main points
Understanding the characteristics that affect slow flight and how to perform this maneuver is an extremely important part of a pilot's training. Slow flight develops the student's awareness of the characteristics, feel and control responses during flight at slow speed (takeoff, climb, landings and go-arounds) to maintain safe flight, and avoid unintentional stalls.

Private Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500 'AGL (ASEL) or 3,000' AGL (AMEL).
2. Maintain altitude, ±100'; heading, ±10°; airspeed +10/-0 knots; and angle of bank, ±10°.

Commercial Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500 'AGL (ASEL) or 3,000' AGL (AMEL).
2. Maintain the altitude, ±50'; heading, ±10°; airspeed +5/-0 knots; and angle of bank, ±5°.

X.B. Demonstration of Flight Characteristics

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), POH/AFM

Objectives	The learner develops an understanding of flight characteristics and power required at different airspeeds and configurations appropriate to the make and model of airplane flow, can apply that knowledge, manage associated risks, and provide effective instruction.
Key Elements	1. Region of Reversed Command 2. Slower Speeds Require Larger Control Movements 3. Stay Coordinated
Elements	1. Stall Aerodynamics 2. Various Factors & Stalls 3. Airspeeds 4. Control Inputs, Configuration, & Airspeed 5. Demonstrating Flight Characteristics 6. Common Errors 7. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the demonstration can be performed and described to ACS standards.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Overview

Review Objectives and Elements/Key ideas

What

A demonstration of the control inputs, power, trim, and aircraft performance in various phases of flight and configurations.

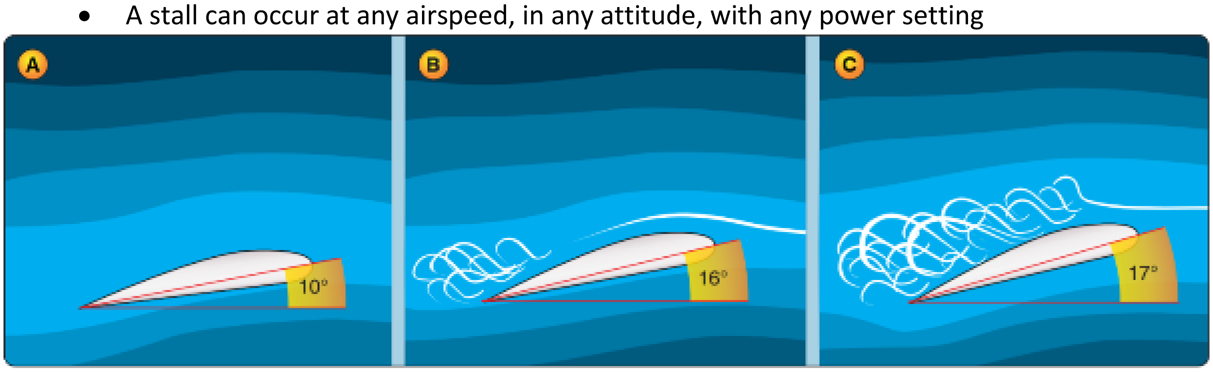
Why AI.X.B.K1

This demonstration provides the learner with a baseline for the changing pitch attitudes, power settings, trim requirements, etc. as airspeed and configuration is varied between the clean and landing configurations. This knowledge can be applied to numerous maneuvers and situations going forward.

How:

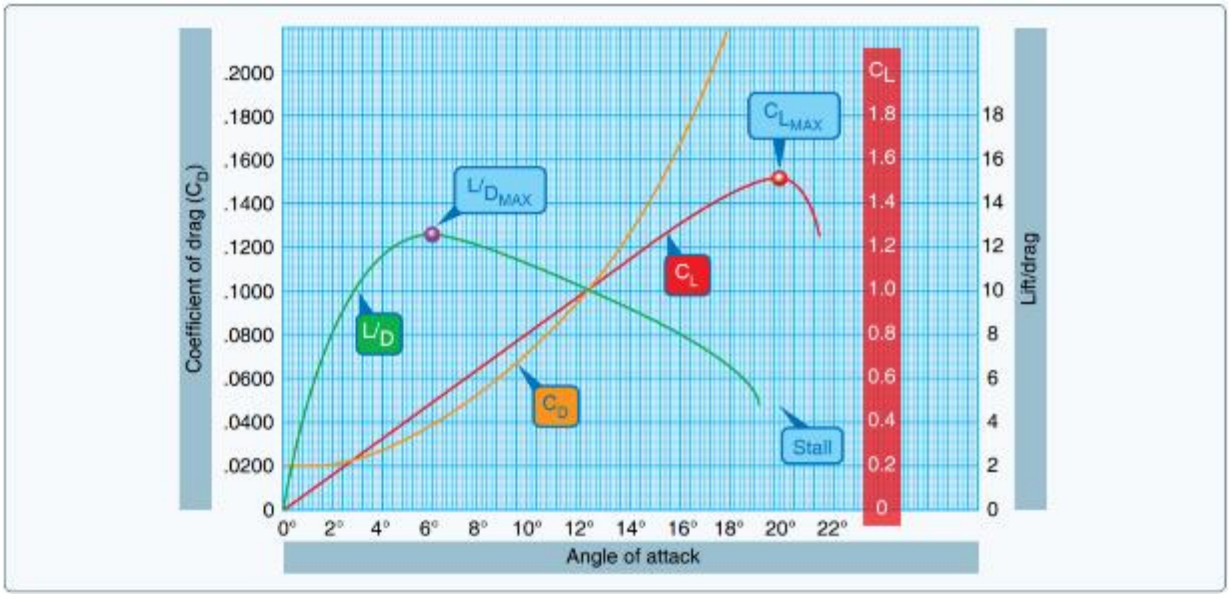
1. Stall Aerodynamics AI.X.B.K4

A. Why an Aircraft Stalls
   i. Basically…
      a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
         - This happens when the wing exceeds its critical angle of attack (AOA)
            a The critical AOA varies between aircraft, but is usually around 15-20º in a GA aircraft
            b Remember, AOA is the angle between the chord line of the wing and the relative wind
         - A stall can occur at any airspeed, in any attitude, with any power setting



      b. The Critical Angle of Attack/C_{LMAX}
         - The point at which the airflow separates and there is a rapid reduction in lift is the stalling angle of attack, or the critical AOA, or C_{LMAX} (the Maximum Coefficient of Lift) – see the diagram below
            a C_L = Coefficient of Lift – A way to measure lift as it relates to the angle of attack
               1. Determined by wind tunnel tests and based on airfoil design and angle of attack

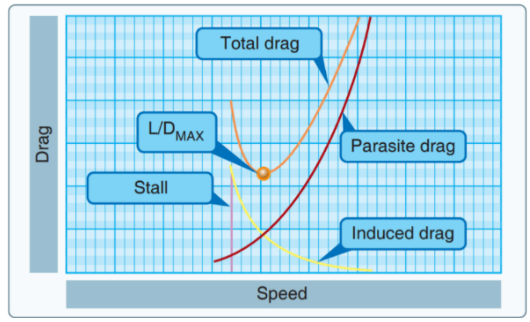
b Any angle of attack beyond C_{LMAX} results in a stall and lift drops off rapidly



B. There's More than One Way to Exceed the Critical AOA
  i. An aircraft can stall at any speed, attitude, or power setting
  ii. Low Speed
    a. As airspeed decreases, the AOA must be increased to maintain altitude
    b. Eventually, an AOA is reached that results in the wing not producing enough lift to support the aircraft. If the airspeed is reduced further, the aircraft stalls because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
  iii. High Speed
    a. Low speed is not necessary to produce a stall, the wing can exceed the critical AOA at any speed
      - Ex. If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate change to the flight path
        a AOA changes abruptly from quite low to very high, but even though the nose has been raised, the aircraft continues on its trajectory downward for some amount of time
    b. If AOA is suddenly increased and the flight path remains the same, the aircraft reaches the critical AOA at a speed much higher than the published stall speed
  iv. Turns
    a. The stall speed of an aircraft is higher in a level turn than in straight-and-level flight
    b. In a turn, the wings must produce additional lift to maintain altitude
      - Remember, in a turn the vertical component of lift is divided into a horizontal & vertical component
    c. Additional lift comes from added back pressure which increases the AOA
      - The flight path/relative wind remain the same, while the pitch is increased, leading to a higher AOA
    d. If at any time during the turn the AOA becomes excessive, the aircraft will stall
  v. Recap: If at *ANY* time (low/high speed or power, straight/turning, etc.) AOA becomes excessive it will stall

2. Various Factors & Stalls AI.X.B.K4

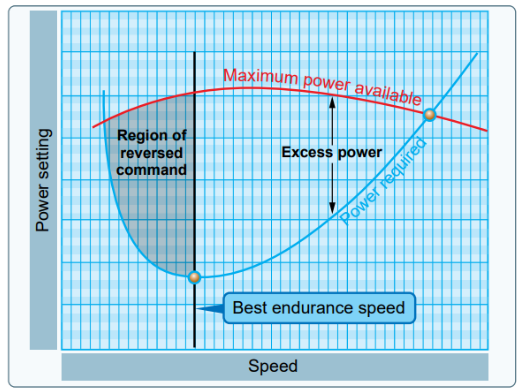
A. Power & Airspeed
  i. Airspeed
    a. An increase or decrease in airspeed increases or decreases lift, affecting AOA and attitude
      - As airspeed decreases, AOA must be increased to maintain lift and altitude (and vice versa)
  ii. Power
    a. Normal vs Reversed Command



- Normal Command
  - a While holding a constant altitude, a higher speed requires a higher power setting & vice versa
  - b Majority of aircraft flying is done here (climb, cruise, maneuvers)
- Region of Reversed Command
  - a A higher airspeed requires a lower power setting, and a lower airspeed requires a higher power setting
  - b Does not imply that a decrease in power produces a lower airspeed

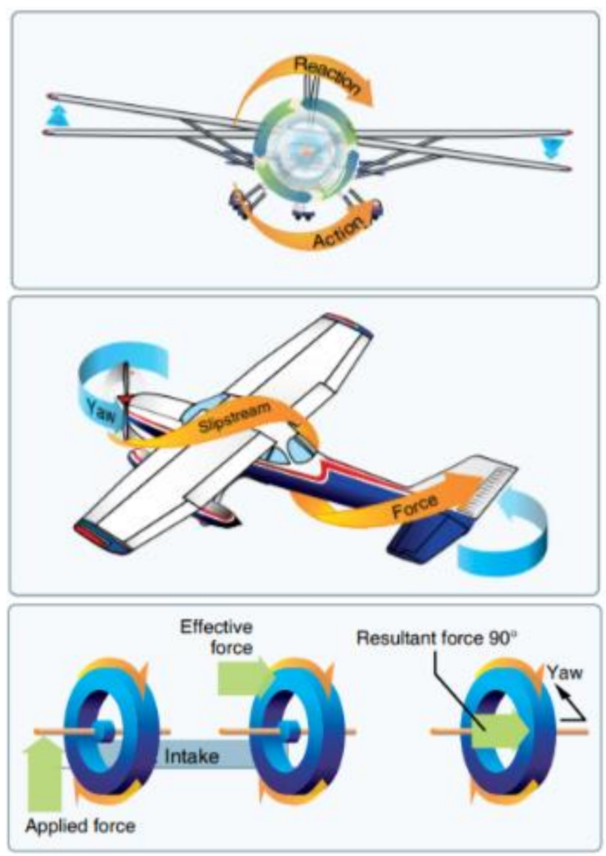
b. Minimum Power Required Airspeed

AI.X.B.K3



- Generally,
  - a Aircraft aerodynamic properties determine the power required at various conditions
  - b Powerplant capabilities determine the power available at various conditions
  - c Visualized on the power required curve (pictured)
- Lowest point on the curve is the speed at which the lowest brake horsepower sustains level flight
  - a Best endurance speed, or minimum power required airspeed
- Best endurance speed delineates the region of reversed command and normal command

B. Yaw Effects

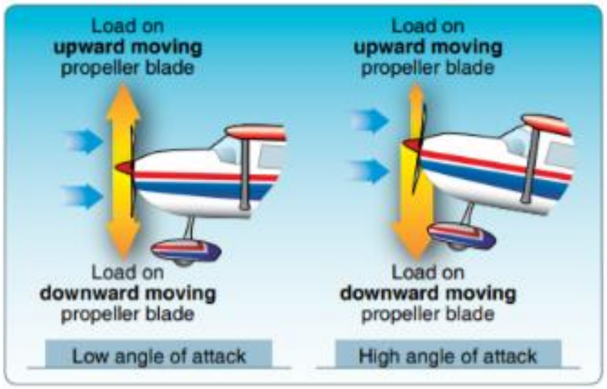


i. Increased power at slow airspeeds and high angles of attack results in increased left turning tendencies
  a. Anticipate considerable right rudder to maintain coordination

ii. Torque Reaction
  a. Newton's 3rd Law – Every action has an equal/opposite reaction
    - The engine/propeller rotate one way; an equal force tries to rotate the plane the opposite direction
  b. Although torque reaction is more of a rolling tendency than a yaw effect, it does contribute to the left turning tendencies

iii. Corkscrew/Slipstream Effect
  a. The high-speed rotation of the propeller sends air in a corkscrew rotation to the rear of the aircraft
    - Air strikes the left side of the vertical stabilizer, pushing the nose of aircraft left
  b. At high propeller speeds/low forward speeds (like in slow flight) the rotation is compact & pronounced
    - Exerts a strong sideward force on the vertical tail causing yaw to the left
    - As forward speed increases, the spiral elongates

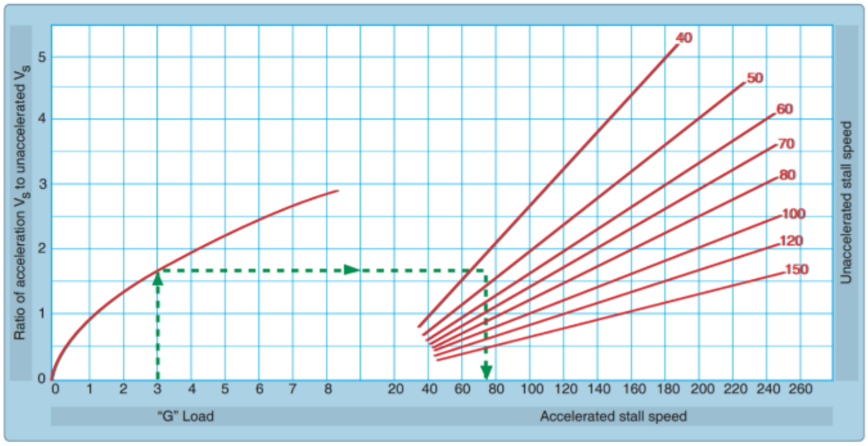
and becomes less effective
   c. Countered with coordinate rudder and aileron
  iv. Gyroscopic Action
   a. Gyroscopes are based on two fundamental principles:
    - Rigidity in space (not applicable to this discussion)
    - Precession - The resultant action of a spinning rotor when a force is applied to its rim
     a If a force is applied, it takes effect 90° ahead of, and in the direction of turn
      1. Causes a pitch/yaw moment or combo of the two depending on where applied
    - Any yawing around the vertical axis results in a pitching moment
    - Any pitching around the lateral axis results in a yawing moment
   b. In relation to slow flight, lifting the nose results in a yaw to the left
    - Correction is made with elevator and rudder pressures to maintain pitch attitude & coordination

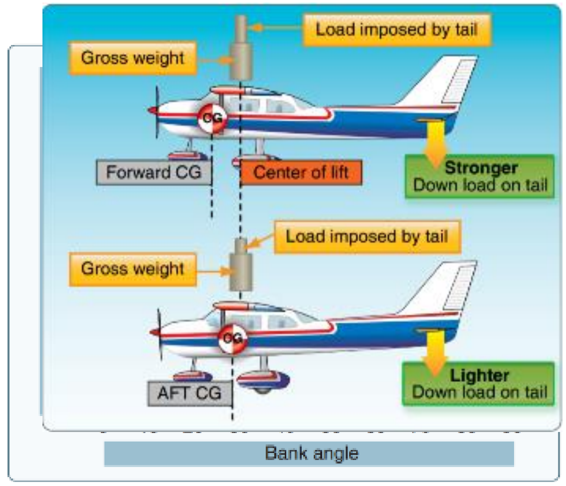


  v. Asymmetric Loading (P Factor)
   a. When flying at a high AOA, the bite of the down moving blade is greater than the up moving blade
    - Moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)
   b. In relation to slow flight, the high AOA results in an increase in p-factor – counter with right rudder
  vi. Big Picture
   a. Considerable right rudder is required to maintain coordination during slow flight
   b. When introducing turns:
    - A right turn requires even more right rudder
    - A left turn requires less right rudder (still requires right rudder)

C. Load Factors
  i. Load factor: Ratio of the total load acting on the aircraft to the gross weight of the aircraft
   a. Expressed in terms of Gs
  ii. Any increase in load factor increases stall speed
  iii. Turns
   a. Increased load factors are a characteristic of all turns
   b. Load factor increases at a high rate after 45°-50° of bank
    - At approx. 63° of bank the stall speed is increased by approximately ½
  iv. Slow Flight & Controllability
   a. In slow flight the airplane is already very close to the stall speed
   b. The increased load factor associated with a turn in slow flight can quickly put the aircraft into a stall
    - Use gentle, coordinated, low bank turns during slow flight to prevent a potential stall
     a 10° of bank is generally a good target (depending on the aircraft)

c. Do not use aggressive control inputs – slow and smooth





D. Weight
  i. The heavier an aircraft, the more lift required to maintain altitude
    a. As more lift is required, the AOA required to maintain level flight is increased
      - An increased AOA brings the aircraft closer to the critical AOA, and therefore the stall speed will be reached sooner (at a higher airspeed) than if the aircraft were lighter
  ii. A heavier aircraft is more stable than a lighter aircraft
    a. Generally, though, the position of the center of gravity has more effect on the stability (more below)
    b. It takes more force to move a heavier object than a lighter one
  iii. Slow Flight & Weight
    a. Because a heavier aircraft is at a higher AOA for a given airspeed, less pitch change is required to reach the critical AOA
    b. The increased weight and stability may help in controlling the aircraft

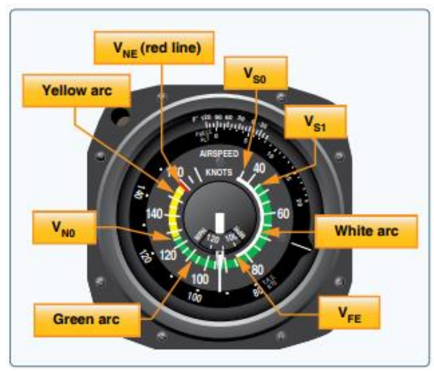
E. Center of Gravity & Controllability
  i. Forward Loaded Aircraft
    a. The aircraft acts heavier, and consequently slower (for a given power setting) than the same aircraft with a further aft center of gravity
      - More nose up elevator pressure and/or trim is required to maintain altitude
      - The higher nose requires the tail surface to produce a greater down load
      - The increased down load adds to the wing loading and results in an increase in the total lift required to maintain altitude
    b. The higher AOA results in more induced drag and a higher stall speed (like a heavy aircraft)
    c. Controllability
      - A forward loaded aircraft is more controllable than an aft loaded aircraft
        a Due to the longer arm from the elevator to the center of gravity
        b Weight x Arm = Moment. The longer the arm, the greater the moment and thus more controllable the aircraft
  ii. Aft Loaded Aircraft
    a. The aircraft acts lighter, and consequently faster (for a given power setting) than the same aircraft with a further forward CG
      - Less nose up elevator pressure/trim is required to maintain altitude
      - The lower nose requires less of a down load from the tail
      - The decreased down load reduces wing loading and decreases total lift required to maintain altitude
    b. The lower AOA results in less induced drag allowing for faster cruise speed and a lower stall speed
    c. Controllability

- Recovery from a stall becomes progressively more difficult as the center of gravity moves aft
  - a Moving the CG aft shortens the arm, reducing the amount of force it can apply
  - b Weight X Arm = Moment. Shorter arm = smaller the moment, therefore less controllable

F. Configuration (Gear and Flaps)
  i. Flaps
    a. Reduce the stall speed of an aircraft
      - Most flaps increase the camber of the wing and change the chord line, producing more lift
        - a The nose of the aircraft is lowered to prevent ballooning
        - b Generally, the lowered nose and additional lift assist in decreasing the stall speed (factors will vary based on aircraft/flap design)
      - Note the differing speeds on the airspeed indicator (green arc vs white arc)
  ii. Gear
    a. The effects of gear can vary based on the aircraft design and characteristics
    b. Gear extension increases drag and if not properly compensated for could lead to a stall
      - Ex. Gear down and a low power setting, combined with increasing pitch to maintain altitude

3. Airspeeds (Review the following airspeeds in the POH, as applicable) AI.X.B.K7

A. White Arc
  i. Flap operating range AI.X.B.K7c, AI.X.B.K7f
  ii. Lower Limit of the White Arc (V_{S0})
    a. Power-off stall speed at the maximum landing weight in the landing configuration (gear & flaps down)
  iii. Upper Limit of the White Arc (V_{FE})
    a. Maximum speed with the flaps extended
  iv. Flaps Operating Speed (V_{FO})
    a. Highest speed permissible for extending/retracting the flaps
    b. Not depicted



B. Green Arc
  i. Normal operating range of the aircraft
  ii. Lower Limit of the Green Arc (V_{S1}) AI.X.B.K7f
    a. Power-off stall speed at the max takeoff weight in the clean configuration (flaps/gear up, if retractable)
  iii. Upper Limit of the Green Arc (V_{NO})
    a. Maximum structural cruising speed
    b. Do not exceed except in smooth air

C. Yellow Arc
  i. Caution range
    a. Fly in this range only in smooth air and then only with caution
  ii. Red Line (V_{NE})
    a. Never exceed speed
    b. Operating above this speed is prohibited – may result in damage or structural failure

D. Other Airspeeds (not depicted)
  i. Best Angle of Climb Speed (V_X)
    a. Speed at which the aircraft gains the most altitude in the shortest distance
  ii. Best Rate of Climb Speed (V_Y)
    a. Speed at which the aircraft gains the most altitude in the shortest time
  iii. Design Maneuvering Speed (V_A) AI.X.B.K7a
    a. Maximum speed at which the limit load can be imposed without causing structural damage
      - Used for maneuvers

b. Doesn't protect against multiple full control inputs in one axis or full control inputs in more than one axis at the same time
c. Varies with weight – higher speed for heavier aircraft

iv. Best Glide Speed (V_{GLIDE}) AI.X.B.K7d
a. Airspeed at which the aircraft glides the furthest for the least altitude lost in non-powered flight

v. Reference Landing Speed (V_{REF}) AI.X.B.K7e
a. Speed flown during the final stages of the approach to landing, generally, 1.3 V_{S0}
- Generally, the min safe speed the aircraft can be landed
- Any slower, may mean that the aircraft stalls, is difficult to control, or develops high rates of descent

b. Landing is accomplished at a particular value of lift coefficient and AOA
- Exact values depend on aircraft characteristics but are independent of weight, altitude, and wind

vi. Landing Gear AI.X.B.K7b
a. Landing Gear Operating Speed (V_{LO})
- Maximum speed for extending or retracting landing gear

b. Landing Gear Extended Speed (V_{LE})
- Maximum speed at which an aircraft can be safely flown with the landing gear extended

E. Reference any other applicable speeds

F. RM: Airspeed Limitations & Airspeed Indicator AI.X.B.R1
(RM: Lack of familiarity with airspeed limitations and indicator interpretation of the airspeed indicator)
i. Published speeds and limitations exist for the sake of safety; operation outside of them is dangerous
a. RM: Exceeding limitations can damage the aircraft (RM: Exceeding airspeed limitations) AI.X.B.R2
b. Incorrect airspeeds can negate performance data

ii. Understand the airspeed indicator & its markings
a. Know the colors, associated speeds, their meanings, and implications
b. There's no time to reference the POH for this information during takeoff, landing, a stall, etc.

4. Control Inputs, Configuration, & Airspeed AI.X.B.K5

Note: Generic info below, adjust/describe based on the specific aircraft

A. Level Flight
i. Review cruise pitch, power, & trim settings
ii. As the airspeed slows, back pressure is increased to maintain altitude
a. The more back pressure, the more trim required
iii. Power is initially reduced, but will have to be increased entering the region of reversed command
iv. Higher power settings require greater right rudder to counter left turning tendencies

B. Turns
i. Review turn pitch, power, & trim settings
ii. Back pressure is required to maintain altitude – lift is divided between a horizontal & vertical component
a. The slower the aircraft, the greater the back pressure
iii. Power is required to maintain airspeed – additional lift increases drag
a. More back pressure and right rudder
iv. Adverse yaw – increased lift and drag on the outside wing requires rudder in the direction of turn
v. Overbanking Tendency: The greater the difference in lift between the wings, the greater the opposite aileron required to maintain bank
a. Slower the aircraft, the greater the overbanking tendency

C. Climbs
i. Review climb pitch, power, & trim settings
ii. Region of Normal Command
a. Pitch for altitude (to climb)
b. Power for airspeed

- iii. With the aircraft pitched up, a component of weight acts alongside drag
    - a. Additional power is required to maintain airspeed
- iv. Region of reversed command
    - a. Pitch for airspeed & power for altitude (to climb)
    - b. Right rudder to counter left turning tendencies

D. Descents
- i. Review descent pitch, power, & trim settings
- ii. A component of weight acts alongside thrust
    - a. If power is reduced, lower pitch to maintain speed
    - b. If pitch is lowered, reduce power to maintain airspeed
- iii. Changes in pitch require trim adjustment

E. RM: Critically Slow Airspeeds (RM: Maneuvering at critically slow airspeeds) AI.X.B.K2, AI.X.B.R9
- i. RM: Region of Reversed Command AI.X.B.R3
  (RM: Flight characteristics in the region of reversed command and the potential for loss of control)
    - a. Precise aircraft control is required at critically slow airspeeds
        - Imperative to understand the concepts and flight characteristics associated with these speeds
    - b. Requires more power to maintain level flight at slower airspeeds
    - c. Pitch for airspeed, power for altitude
    - d. Control & Power
        - High power and pitch attitude to maintain level flight
        - Less effective controls requiring bigger movements
        - Significant right rudder to maintain coordination
        - Overbanking tendency is prevalent
    - e. A lack of understanding and/or ability could rapidly lead to a loss of control
        - Common sense does not prevail in the region of reversed command
- ii. RM: Stall Indications (Warning Range & Limitations) AI.X.B.R5
    - a. Decreased noise as the aircraft slows
        - Controls become sluggish/less effective
    - b. Buffet: Tends to occur prior to the stall horn
        - Generally, an early indication of a stall
        - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
    - c. Stall Horn
        - Designed to provide warning of an approaching stall and time for stall recovery
        - Per 23.207
            - a Clear/distinct warning with the flaps and gear in any normal position, in straight & turning flight
            - b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
            - c Must provide the pilot time to take action to avert the stall
    - d. Stall indications and horns have different operational ranges and limitations
        - Reference the POH for specific information
        - Ex: Uncoordinated flight may inhibit airflow at the stall indicator
            - a Situations where one wing (without the indicator) stalls first
- iii. RM: Unacknowledged Stall Indications AI.X.B.R6
    - a. Unacknowledged indications can be the result of various factors
        - Unfamiliarity with stall indications, distractions, fear (fight/flight reaction), confusion, etc.
    - b. The farther an aircraft continues into the stall, the more hazardous and the greater loss of altitude
    - c. The student should be familiar with and able to recognize *all* stall indications
        - Noises, control effectiveness, seat of the pants feelings, buffet, stall horn, actual stall behavior

- An ability to recognize some, but not all indications, is dangerous and can delay recovery
- Ensure the student is shown full stalls, and not only taught to recover at the first indication
    - a Rod Machado has a great article on The Stall Horn Fallacy of Stall Prevention

iv. RM: Inadvertent Stall (RM: Inadvertent exceedance of the critical AOA) AI.X.B.R4

a. Recover immediately – this is not the time to figure out what happened or how it happened

b. By ensuring a student can recognize and recover at any stage of a stall, they are far better protected from an inadvertent stall

c. Simply waiting for the stall horn may catch the pilot off guard

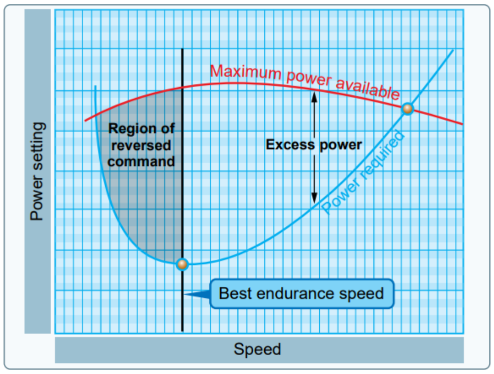
F. Configuration Changes AI.X.B.K6

i. Flaps

a. Settings: List flap settings and their characteristics

b. Generally, as flaps are extended, lift is increased along with drag

- Increased camber and AOA (chord line gets steeper)
- Reduce pitch to maintain altitude
- Increase power to maintain airspeed



ii. Gear

a. Gear introduces considerable drag and can affect the pitching moment

b. Add power to maintain airspeed & adjust pitch to maintain level flight

c. Ability to climb is based on excess thrust/power (pictured)

- The additional power required to maintain altitude with the gear down reduces climb ability
- Greatest combined effect is slow flight (high power required to maintain altitude + drag from gear)

5. Demonstrating Flight Characteristics AI.X.B.K1, AI.X.B.K2

A. Pre-Maneuver

i. Properly clear the area

ii. Pre-maneuver checklist

iii. Select an altitude

a. No lower than 1,500' AGL

b. Select an altitude that is easy to read on the altimeter - 500' increments are easiest

B. Clean Configuration Demo

i. Establish and maintain level flight at maneuvering speed

a. Describe pitch, power, and trim inputs to maintain airspeed/altitude

ii. Slow to and maintain best glide airspeed

a. Note power setting required to maintain best glide speed

b. Describe changes in pitch, trim, control pressures/control feel and coordination requirements

iii. Slow to a speed at which any increase in AOA, load factor, or power reduction would result in a stall (V_{S1})

a. Describe changes in pitch, trim, control pressures and feel, right rudder requirements

b. Describe power required to maintain level flight (note change in noise, AOA, etc.)

c. Verbally acknowledge stall indications

iv. Without changing power, lower pitch and accelerate until reestablishing level flight

a. Note the new airspeed and altitude lost

v. Return to normal cruise flight

C. Landing Configuration Demo

i. Maintain maneuvering speed at the selected altitude

a. Describe pitch, power, and trim inputs to maintain airspeed/altitude

ii. While maintaining altitude, slow to the limiting airspeeds and fully extend gear and flaps
iii. Once configured, slow to and maintain reference landing speed
  a. Note power required and changes in trim and control pressures and control feel
iv. Slow to a speed at which an increase in AOA, load factor, or power reduction would result in a stall (V_{S0})
  a. Maintain this airspeed in level flight
  b. Note airspeed and power setting, as well as control inputs and trim
  c. Verbally acknowledge stall indications
v. Without changing power, lower pitch and accelerate to until reestablishing level flight
  a. Note the new airspeed and altitude lost
vi. Return to normal cruise flight at the heading & altitude specified

6. Common Errors (duplicated from Slow Flight due to similarities and because none are in the AFH) AI.X.B.K8
  A. Failure to adequately clear the area
  B. Inadequate back-elevator pressure as power is reduced, resulting in altitude loss
  C. Excessive back-elevator pressure as power is reduced, resulting in a climb followed by rapid reduction in speed
  D. Insufficient right rudder to compensate for left yaw
  E. Fixation on the flight instruments
  F. Failure to anticipate changes in AOA as flaps are extended or retracted
  G. Inadequate power managements
  H. Inability to adequately divide attention between airplane control & orientation
  I. Failure to properly trim the airplane
  J. Failure to respond to a stall warning

7. Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.
  A. X. RM Concepts – Environmental Elements AI.X.B.R7
  B. X. RM Concepts – Collision Hazards AI.X.B.R8

Conclusion:

Brief review of the main points

Instructor ACS Skill Standards

1. Conduct and explain the procedure, manage the associated risk, and fly the airplane, while maintaining altitude ±100’, airspeed +5/-0 knots, heading ±10°, and specified bank angle ±5°, as appropriate.

X.C. Power-Off Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Stall and Spin Awareness Training (AC 61-67), POH/AFM

Objectives	The learner should develop knowledge of power-off stalls including aerodynamics, factors associated with stall speeds, as well as proper recovery techniques. The learner will understand situations in which power off stalls are most common and most dangerous and can perform a power-off stall as required in the ACS.
Key Elements	1. Critical Angle of Attack 2. Reduce the AOA 3. Disconnect, Pitch, Roll, Thrust, Stabilize, Configure
Elements	1. Aerodynamics 2. Various Factors and their Effect on Stall Speed 3. Power-Off Stall Situations 4. Power-Off Stalls 5. Common Errors 6. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner is familiar with the conditions that produce power-off stalls and develops the habit of taking prompt preventative and/or corrective action at the first indication of a stall.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Stalls can be intimidating/frightening but understanding how they work and practicing them will make you more comfortable with them, and a safer pilot. A stall can occur at any airspeed, in any attitude, or any power setting.

Overview

Review Objectives and Elements/Key ideas

What

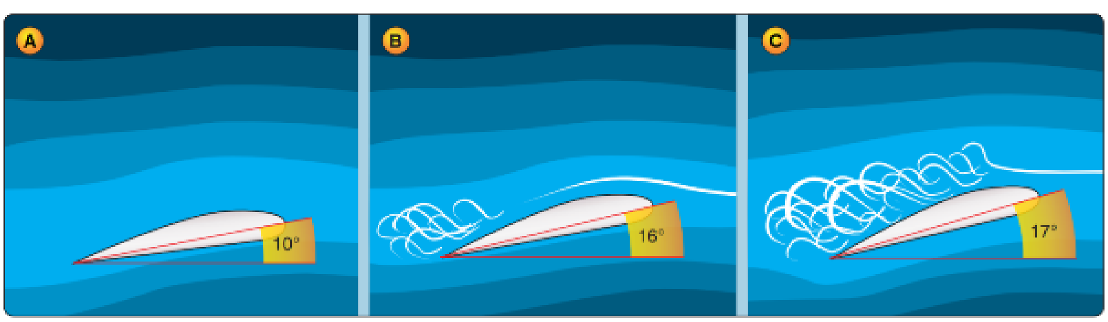
A stall occurs when the critical AOA is exceeded. When this happens, the smooth airflow over the wing is disrupted resulting in a loss of lift and increased drag. Power off stalls simulate stalls in the approach and landing configuration.

Why AI.X.C.K1

In general, stalls are practiced to become familiar with an aircraft's particular stall characteristics and to avoid putting the aircraft into a potentially dangerous situation. Power-off stalls are essential to understanding the aircraft's stall characteristics in the landing configuration. It is important to understand how they happen, how to avoid them, and how to recover from them.

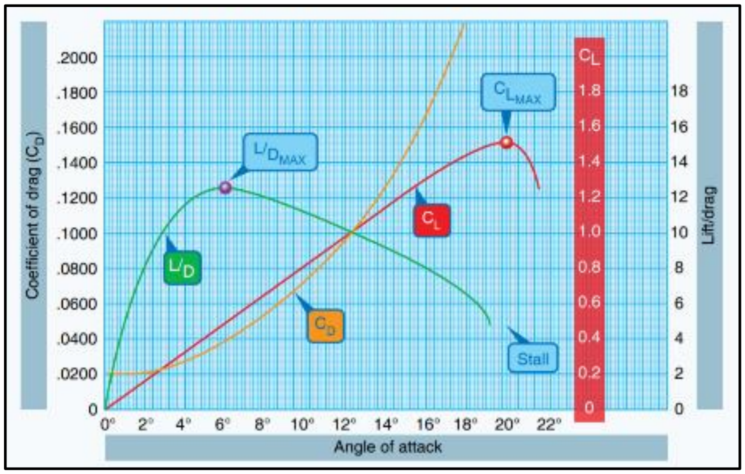
How:

1. **Aerodynamics** AI.X.C.K2
   B. Why an Aircraft Stalls
      i. Basically…
         a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
            - This happens when the wing exceeds its critical angle of attack (AOA)
               a The critical AOA varies between aircraft, but is usually around 15-20º in a GA aircraft
               b Remember, AOA is the angle between the chord line of the wing and the relative wind
            - A stall can occur at any airspeed, in any attitude, with any power setting
      ii. More Specifically…
         a. Airflow Over the Wing
            - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in graphic below)
            - As AOA increases, airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in the graphic below)
            - As AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift, leading to airflow separation and a stall (C in graphic below)
               a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of airflow from the



wing's surface

b. The Critical Angle of Attack/C_{LMAX}
   - The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
   - C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
     a Determined by wind tunnel tests and based on airfoil design and AOA
   - Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly

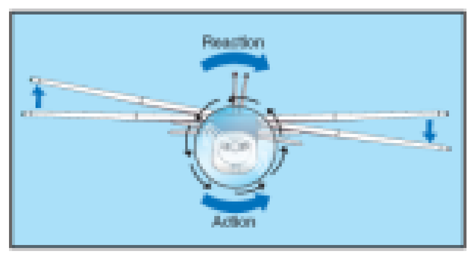


C. Stall Characteristics
   i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips
      a. By having the root stall first, aileron effectiveness is maintained, maintaining controllability
   ii. Various design can be used to accomplish this:
      a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
         - Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
         - These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip
      b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than otherwise

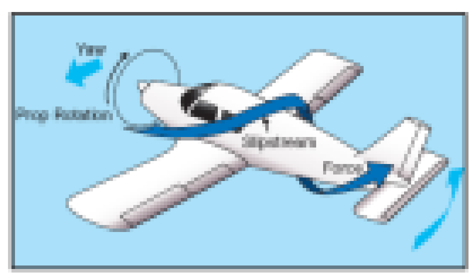
D. There's More than One Way to Exceed the Critical AOA
   i. An aircraft can stall at any speed, attitude, or power setting
   ii. Low Speed
      a. As airspeed decreases, the AOA must be increased to maintain altitude
      b. Eventually, an AOA is reached that results in the wing not producing enough lift to support the aircraft. If the airspeed is reduced further, the aircraft stalls because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
   iii. High Speed
      a. Low speed is not necessary to produce a stall, the wing can exceed the critical AOA at any speed
         - Ex. If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate change to the flight path
           a AOA changes abruptly from quite low to very high, but even though the nose has been raised, the aircraft continues on its trajectory downward for some amount of time
      b. If AOA is suddenly increased and the flight path remains the same, the aircraft reaches the critical AOA at a speed much higher than the published stall speed
   iv. Turns
      a. The stall speed of an aircraft is higher in a level turn than in straight-and-level flight
      b. In a turn, the wings must produce additional lift to maintain altitude
         - Remember, in a turn the vertical component of lift is divided into a horizontal & vertical component
      c. Additional lift comes from added back pressure which increases the AOA
         - The flight path/relative wind remain the same, while the pitch is increased, leading to a higher AOA
      d. If at any time during the turn the AOA becomes excessive, the aircraft will stall
   v. Recap: If at *ANY* time (low/high speed or power, straight/turning, etc.) AOA becomes excessive it will stall

3. Various Factors and their Effect on Stall Speed AI.X.C.K2

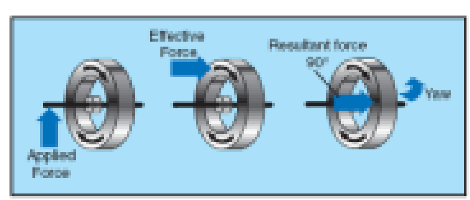
A. A stall can occur at any airspeed, attitude, or power setting, depending on the total factors affecting the aircraft
B. Airspeed & Power Settings
    i. As mentioned above, a stall can occur at any airspeed
        a. Low Speed and/or Low Power Setting
            - As airspeed decreases, AOA must be increased to maintain altitude
            - Eventually, an AOA is reached that results in the wing stalling because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
        b. High Speed and/or High-Power Setting
            - If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate alteration of the flight path
                a Since the AOA is suddenly increased while the flight path remains the same, the aircraft reaches the critical AOA at a speed much higher than the published stall speed
                b More on load factors/accelerated stalls below
            - Depending on the aircraft, a higher power setting may help to reduce the stall speed and increase the lift on the wings
                a Although the wing may be stalled, a higher power setting can provide increased lift due to the propeller airflow/prop wash moving over the wing roots
                b More prominent in low wing aircraft where the propeller airflow moves directly over the wing
                c This airflow also likely has a relatively low angle of attack
    ii. Increased power at slow airspeeds and high angles of attack results in increased left turning tendencies
        a. Anticipate considerable right rudder to maintain coordination
C. Yaw Effects
    i. Increased power at slow airspeeds and high AOA (like stall recovery) aggravates left turning tendencies
        a. Anticipate considerable right rudder to maintain coordination
    ii. Torque Reaction



        a. Newton's 3rd Law – Every action has an equal/opposite reaction
            - The engine/propeller rotate one way; an equal force tries to rotate the plane the opposite direction
        b. Although torque reaction is more of a rolling tendency than a yaw effect, it does contribute to the left turning tendencies
        c. Be mindful as power is increased in the stall recovery
    iii. Corkscrew/Slipstream Effect
        a. The high-speed rotation of the propeller sends air in a corkscrew rotation to the rear of the aircraft
            - Air strikes the left side of the vertical stabilizer, pushing the nose left



        b. At high propeller speeds/low forward speeds (like in a power-off stall recovery) the rotation is compact & pronounced
            - Strong force on the vertical tail causing yaw to the left
            - As forward speed increases, the spiral elongates and becomes less effective
        c. Countered with coordinate rudder and aileron
    iv. Gyroscopic Action
        a. Gyroscopes are based on two fundamental principles:
            - Rigidity in space (not applicable to this discussion)
            - Precession - Resultant action of a spinning rotor when a force is applied to its rim
                a When a force is applied, it takes effect 90° ahead of,



and in the direction of turn

1. Causes a pitch/yaw moment or combo of the two depending on where applied

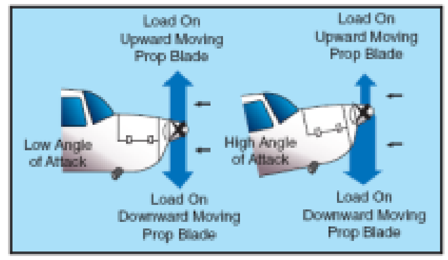
b Any yawing around the vertical axis results in a pitching moment

c Any pitching around the lateral axis results in a yawing moment

b. In relation to power-off stalls, lifting the nose results in a yaw to the left
   - An aggressive power push can result in the nose rising rapidly
   - Correction is made with elevator and rudder pressures to maintain pitch attitude & coordination

v. Asymmetric Loading (P-Factor)

a. When flying at a high AOA, the bite of the down moving blade is greater than the up moving blade
   - Moves the center of thrust to the right of the propeller disc area causing a yaw to the left



b. In relation to power-off stalls, the power increase at a high AOA increases P-factor
   - Compensated for with right rudder

vi. Big Picture

a. Considerable right rudder is required to maintain coordination during a power-off stall recovery

b. When turning:
   - A right turn requires even more right rudder
   - A left turn requires less right rudder (still requires right rudder)

D. Configuration (Gear and Flaps)

i. Flaps

a. Reduce the stall speed of an aircraft
   - Most flaps increase the camber of the wing and change the chord line, producing more lift
     a The nose of the aircraft is lowered to prevent ballooning
     b Generally, the lowered nose and additional lift assist in decreasing the stall speed (factors will vary based on aircraft/flap design)
   - Note the differing speeds on the airspeed indicator (green arc vs white arc)

ii. Gear

a. The effects of gear can vary based on the aircraft design and characteristics

b. Gear extension increases drag and if not properly compensated for could lead to a stall
   - Ex. Gear down and a low power setting, combined with increasing pitch to maintain altitude

E. Weight

i. As the weight of the aircraft is increased, the stall speed increases

a. Remember, to maintain altitude lift must equal weight

b. So, the greater the weight, the greater the lift required

c. A higher AOA is required to generate the lift (all other factors remaining the same)

d. The higher AOA puts the aircraft closer to the critical AOA; thus, the aircraft will stall at a higher speed

ii. A lighter aircraft will stall at a slower airspeed

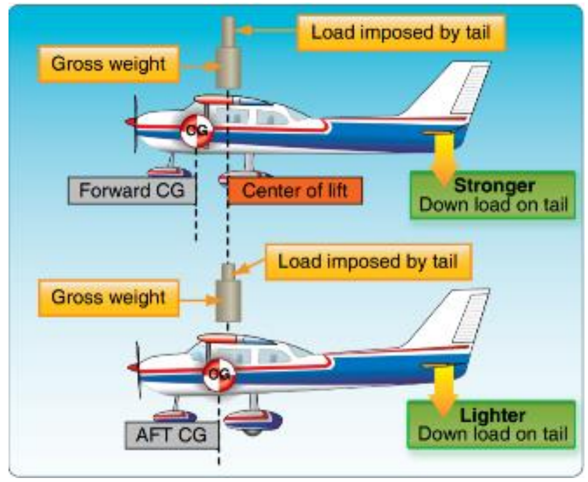
a. Same as above, but opposite. Less lift is required, and the AOA can be reduced (all other factors remaining the same), lowering the stall speed

F. Center of Gravity

i. Forward Center of Gravity (CG)

a. Increases the stall speed

b. A forward center of gravity has the same effect on stall speed as a heavier aircraft
   - The farther forward the center of gravity moves, the higher the angle of attack has to be to compensate for the extra load imposed by the tail (see picture)



- Due to the higher AOA, the aircraft is closer to the critical AOA and therefore will stall at a higher speed

c. The aircraft is also more controllable due to the longer arm from the CG to the elevator, improving the stall recovery capabilities
  - Additionally, the farther forward the CG, the greater the tendency for the nose to pitch down
    - a Imagine it as more "nose heavy"

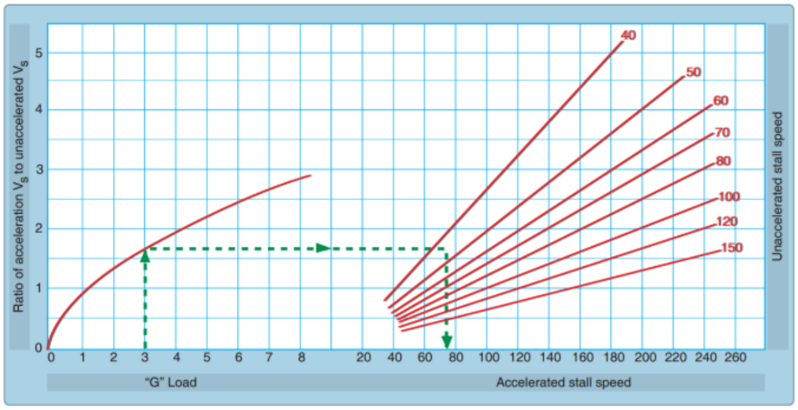
d. Worth noting:
  - The higher AOA and increased deflection of the stabilizer increases drag; thus, the aircraft is slower for a given power setting

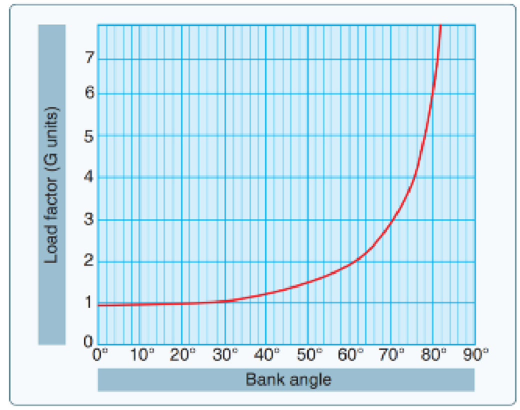
ii. Aft CG
  a. Decreases the stall speed
  b. An aft center of gravity has the same effect on stall speed as a lighter aircraft
    - The farther aft the CG, the lower the AOA has to be to compensate for the load imposed by the tail
    - Due to the lower AOA, the aircraft is farther from the critical AOA and will stall at a lower speed
  c. Although stall speed is lower, the aircraft is less controllable due to the shorter arm from CG to elevator
    - Shortened arm produces less force making recovery more difficult
    - As the CG moves aft, recovery from a stall becomes progressively more difficult
    - Additionally, the farther aft the CG, the less tendency for the nose to pitch down on its own
      - a Imagine it as more "tail heavy"
  d. Worth noting:
    - The lower AOA and less downward deflection of the stabilizer reduces drag; thus the aircraft is faster for a given power setting

G. Load Factor
  i. Increased load factor increases the stall speed
  ii. Load factor is the ratio of the total load acting on the aircraft to the gross weight of the aircraft
    a. Expressed in terms of Gs
  iii. Any increase in the load factor increases the stall speed
    a. The stall speed increases in proportion to the square root of the load factor
    b. When an aircraft is stalled at a higher than indicated air speed due to excessive maneuvering loads, it is called an accelerated maneuver stall
  iv. Pulling out of a steep descent, steep turns, aggressive control inputs, etc. Anything that puts Gs on the aircraft can increase the load factor and therefore the stall speed

H. Bank Angle & Load Factor
  i. Increased bank angle increases the stall speed
  ii. Increased load factors are a characteristic of all banked turns
  iii. Tremendous loads are imposed as bank is increased beyond 45°
    a. At a 60° bank, a load factor of 2 Gs is imposed on the airplane structure
    b. At a 70° bank, a load factor of approximately 3 Gs is placed on the airplane

c. At approx. 63° of bank the stall speed is increased by approximately ½





I. Snow, Ice, and Frost
   i. Increase the stall speed
   ii. Snow, ice and frost disrupt the smooth flow of air over the wing causing the boundary layer to separate at an angle of attack lower than the critical angle of attack
      a. To make matters worse, lift is greatly reduced due to the disrupted air, and if ice accumulates, the weight of the aircraft is increased
         - More lift is required due to the added weight, but less lift is available due to the ice
      b. As little as .8 millimeters of ice on the upper wing increases drag and reduces lift by 25%

3. RM: **Power-Off Stall Situations** AI.X.C.K4, AI.X.C.R1

A. Generally associated with approach to landing conditions and configurations

B. Attempting to recover from a high sink rate on final approach using only an increased pitch attitude
   i. Just pitching, can quickly slow and stall the aircraft resulting in a further increased sink rate

C. Improper airspeed control on final approach and other segments of the traffic pattern
   i. Distractions, disorientation, windshear, poor region of reversed command understanding & control, etc.

D. Maintain a consistent scan and stable approach

4. Power-Off Stalls AI.X.C.K1

A. Entry
   i. *Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
   ii. Clear the Area
   iii. Select an altitude – Recover prior to 1,500' AGL
   iv. *Landing Configuration: Landing Flaps
      a. *Use the same procedure as entering slow flight but maintain (descend at) 65 knots
   v. Note the Heading

B. Getting into the Straight Stall
   i. Slow to normal approach speed while maintaining the originally established altitude
      a. Extend the flaps (landing flaps)
      b. Visually - Find a reference off the nose to maintain direction and to assist with pitch attitude
   ii. Then, smoothly lower the nose to the normal approach attitude and maintain approach speed
   iii. Once stabilized, power should be reduced to idle, and the nose should be smoothly raised to and held at an attitude that will induce a stall
      a. Simulate a flare to landing
      b. Maintain directional control with rudder, wings level with ailerons, pitch with elevator until a stall occurs
      c. Use smooth movements in controlling the airplane, nothing jerky

C. Getting into the Turning Stall
   i. A descending turn uses the same procedures as a straight stall, except a specified bank angle is maintained

a. When the power is set and the descent established, establish the desired bank angle
b. Aileron pressure must be continually adjusted to keep the bank constant
    - Opposite aileron may be necessary when slow due to the overbanking tendency
c. Take care to ensure the aircraft remains coordinated at a constant bank angle until the stall occurs
    - If a slip develops, the outer wing may stall first and move downward abruptly

D. Recognizing the Stall AI.X.C.K3
  i. Announce the onset of the stall
    a. Stall Warning Horn
    b. Reduced Control Effectiveness
    c. Buffet
    d. Stall
  ii. Sight
    a. Attitude of the airplane
  iii. Sound
    a. Stall warning horn
    b. Noise will tend to decrease with airspeed and the lessening flow of air around the aircraft
  iv. Kinesthesia (the sensing of movements by feel, "seat of the pants" sensations, your "spidey sense")
    a. The physical sensation of changes in direction is an important indicator to the trained and experienced pilot in visual flight
    b. If properly developed, it can warn the pilot of an impending stall
      - The pilot can recognize when something doesn't feel right
  v. Feel
    a. Control pressures become progressively less effective (mushy)
      - The lag between control movements and response of the aircraft become greater
    b. Buffeting, uncontrollable pitching or vibrations just before the stall
      - The buffet is caused by the turbulent air flowing over the fuselage/horizontal stabilizer
    c. Leaning back
  vi. Aircraft Specific
    a. Note any aircraft specific designs, indicators, characteristics, etc.
  vii. RM: Stall Warning Range & Limitations AI.X.C.R2
    a. Buffet: Tends to occur prior to the stall horn
      - Generally, an early indication of a stall
      - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
        a Airplane design, attitude, configuration, etc. preventing turbulent air from the wings hitting the stab
    b. Stall Horn
      - Designed to provide warning of an approaching stall and time for stall recovery
      - Per 23.207
        a Clear/distinct stall warning with flaps & gear in any normal position, in straight and turning flight
        b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
        c Must provide the pilot time to take action to avert the stall
    c. Stall indications and horns have different operational ranges and limitations
      - Reference the POH for specific information
      - Ex: Uncoordinated flight may inhibit airflow at the stall indicator
        a Situations where one wing (without the indicator) stalls first

E. RM: Recovery (RM: Stall recovery procedure) AI.X.C.K5, AI.X.C.R4
  i. Basics: Disconnect, Pitch, Roll, Thrust, Stabilize, Configure (perform each step as appropriate)

a. Disconnect the autopilot (if applicable)
b. Pitch nose down
    - Pitch attitude/angle of attack must be decreased positively and immediately
    - The cause of any stall is an excessive angle of attack, decreasing the angle of attack is crucial
    - Be familiar with the control pressures required for your aircraft
        a Excessive pitch down can result in excessive altitude loss
        b Insufficient pitch down will not break the stall
        c If the nose is trimmed up, additional pressure will be required to break the stall
            1. If able/necessary, trim the nose down during the recovery
c. Roll wings level
    - Regain/maintain directional control with coordinated aileron and rudder
    - Reorients the lift vector vertical for a more effective recovery and climb
    - Do not attempt to level the wings prior to reducing angle of attack
        a A stalled wing can roll the opposite direction of aileron input (more info below)
d. Thrust/power as necessary
    - Stalls can occur at high/low power settings and airspeeds so adjust power as required
    - In general, maximum allowable power should be applied to increase airspeed and help increase airflow over the wings, assisting in stall recovery
    - Power is not essential to stall recovery, reducing the AOA is the only way of recovering
    - Right rudder will be required to maintain coordination/heading
        a Use outside references - add rudder to keep the nose from yawing across the horizon
e. Stabilize/establish the desired flight path
    - In this case, perform a go around and climb at the desired airspeed V_Y (V_X if necessary)
f. Configure
    - Once in a climb, configure the aircraft as necessary
    - Same flap and gear retraction procedure as a go around

ii. Ailerons and Recovery
a. Most general aviation aircraft are designed to stall progressively outward from the wing root
    - The wings are designed in this manner so that aileron control will be available at high AOA and give the airplane more stable stalling characteristics
    - During the recovery, the return of lift begins at the tips and progresses towards the roots
        a Thus, ailerons can be used to level the wings
b. If the wing is fully stalled (ailerons included), using the ailerons can aggravate the stall
    - EX: If the right wing dropped, and excessive aileron was applied to raise the wing, the right wing (aileron down) would produce a greater AOA and more (induced) drag
        a Increasing the AOA on an already stalled wing will aggravate the stall on that wing
        b The increase in drag and aggravated stall on the low wing will yaw the aircraft in the direction of that wing and could result in a spin

iii. Rudder and Recovery
   a. The primary cause of an inadvertent spin is exceeding the critical AOA while applying excessive or insufficient rudder and, to a lesser extent, aileron
      - Therefore, it is important that the rudder be used properly during the entry and recovery
   b. The primary use of rudder is to counteract any tendency of the airplane to yaw or slip
      - A smooth controlled recovery is the goal, this will also help to avoid a secondary stall

5. Common Errors (AFH 5-21) AI.X.C.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.
M. Excessive airspeed buildup during recovery.
N. Losing situational awareness and failing to return to desired flightpath or follow ATC instructions.

6. RM: **Hazards**

A. Stall Warning during Normal Operation AI.X.C.R3
   i. Recover
   ii. The first thought is not how and why is this happening, the first reaction is to recover/fix the problem
      a. When safe, then you can figure out how it happened
B. Secondary Stalls AI.X.C.R5
   i. Occurs after recovery from a preceding stall
      a. Pilot does not sufficiently reduce AOA or attempts to recover using power only
   ii. More likely to occur at low altitude, where the natural impulse is to pull up abruptly
   iii. Perform the stall recovery procedure again
   iv. Prevent secondary stalls with proper recovery procedures (Push, Roll, Thrust, Stabilize)
C. Accelerated Stalls AI.X.C.R5
   i. Higher G loads increase the stall speed (Ex. Steep turns, aggressive pull up)
   ii. Use smooth, controlled inputs
   iii. Recover at the first indication
D. Cross-Controlled Stalls AI.X.C.R5
   i. Uncoordinated aileron and rudder in opposite directions can lead to a cross-controlled stall
   ii. Often associated with the traffic pattern, and especially hazardous at low altitudes
      a. Ex. Overshooting final and using rudder to “help the turn” with opposite aileron to maintain 30° bank
   iii. May have little to no warning of the impending stall
   iv. Release the crossed-controls and recover
   v. Prevent cross-controlled stalls by maintaining coordination

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

D. X. RM Concepts – Environmental Elements AI.X.C.R6
E. X. RM Concepts – Collision Hazards AI.X.C.R7
F. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.C.R8

Conclusion:
Brief review of the main points
Exceeding the critical angle of attack causes a stall. A stall can occur at any airspeed, in any attitude, or ay any power setting, depending on the total number of factors affecting the particular airplane.

Private Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500’ AGL (ASEL) or 3,000’ AGL (AMEL).
2. Maintain heading ±10 if in straight flight; maintain specified bank not to exceed 20°, ±10°, in turning flight.

Commercial Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500’ AGL (ASEL) or 3,000’AGL (AMEL).
2. Maintain heading ±10 in straight flight; maintain specified bank not to exceed 20°, ±5°, in turning flight.

X.D. Power-On Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Stall and Spin Awareness Training (AC 61-67), POH/AFM

Objectives	The learner develops knowledge of stalls including aerodynamics, factors associated with stall speeds, as well as proper recovery techniques. The learner understands situations in which power on stalls are most common and most dangerous and can perform a power-on stall as required in the ACS.
Key Elements	1. Critical Angle of Attack 2. Reduce the AOA 3. Disconnect, Pitch, Roll, Thrust, Stabilize, Configure
Elements	1. Aerodynamics 2. Various Factors and their Effect on Stall Speed 3. Power-On Stall Situations 4. Power-On Stalls 5. Common Errors 6. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner is familiar with the conditions that produce power-on stalls and develops the habit of taking prompt preventative and/or corrective action at the first indication of a stall.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Stalls can be intimidating and frightening but understanding how they work and practicing them will make you more comfortable with them and a much safer pilot. A stall can occur at any airspeed, in any attitude, or any power setting.

Overview

Review Objectives and Elements/Key ideas

What

A stall occurs when the critical angle of attack is exceeded. When this happens, the smooth airflow over the wing is disrupted resulting in a loss of lift and increased drag. Power on stalls (also known as departure stalls) are practiced to simulate stalls in the takeoff and climb-out conditions and configuration.

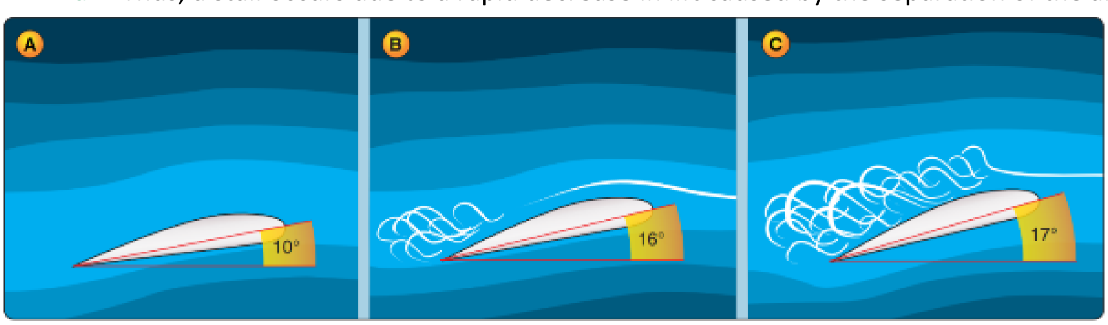
Why AI.X.D.K1

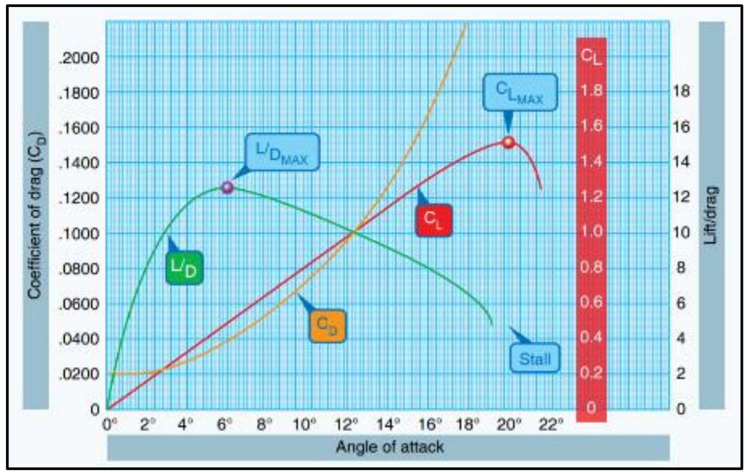
In general, stalls are practiced to become familiar with an aircraft's particular stall characteristics and to avoid putting the aircraft into a potentially dangerous situation. Power-on stalls allow the pilot to become familiar with the stall characteristics in the takeoff configuration.

How:

1. Aerodynamics AI.X.D.K2

A. Why an Aircraft Stalls
   i. Basically…
      a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
         - This happens when the wing exceeds its critical angle of attack (AOA)
            a The critical AOA varies between aircraft, but is usually around 15-20º in a GA aircraft
            b Remember, AOA is the angle between the chord line of the wing and the relative wind
         - A stall can occur at any airspeed, in any attitude, with any power setting
   ii. More Specifically…
      a. Airflow Over the Wing
         - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in graphic below)
         - As AOA increases, the airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in the graphic below)
         - As the AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift, leading to airflow separation and a stall (C in graphic below)
            a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of the airflow from





the wing's surface

- b. The Critical Angle of Attack/C_{LMAX}
  - The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
  - C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
    - a Determined by wind tunnel tests and based on airfoil design and AOA
  - Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly

B. Stall Characteristics
- i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips
  - a. By having the root stall first, aileron effectiveness is maintained, maintaining controllability
- ii. Various design can be used to accomplish this:
  - a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
    - Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
    - These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip
  - b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than otherwise

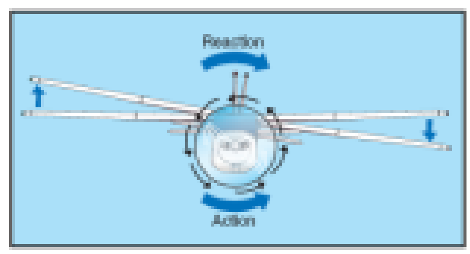
C. There's More than One Way to Exceed the Critical AOA
- i. An aircraft can stall at any speed, attitude, or power setting
- ii. Low Speed
  - a. As airspeed decreases, the AOA must be increased to maintain altitude
  - b. Eventually, an AOA is reached that results in the wing not producing enough lift to support the aircraft. If the airspeed is reduced further, the aircraft stalls because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
- iii. High Speed
  - a. Low speed is not necessary to produce a stall, the wing can exceed the critical AOA at any speed
    - Ex. If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate change to the flight path
      - a AOA changes abruptly from quite low to very high, but even though the nose has been raised, the aircraft continues on its trajectory downward for some amount of time
  - b. If AOA is suddenly increased and the flight path remains the same, the aircraft reaches the critical AOA at a speed much higher than the published stall speed
- iv. Turns
  - a. The stall speed of an aircraft is higher in a level turn than in straight-and-level flight
  - b. In a turn, the wings must produce additional lift to maintain altitude
    - Remember, in a turn the vertical component of lift is divided into a horizontal & vertical component
  - c. Additional lift comes from added back pressure which increases the AOA
    - The flight path/relative wind remain the same, while the pitch is increased, leading to a higher AOA
  - d. If at any time during the turn the AOA becomes excessive, the aircraft will stall
- v. Recap: If at *ANY* time (low/high speed or power, straight/turning, etc.) AOA becomes excessive it will stall

2. Various Factors and their Effect on Stall Speed AI.X.D.K2

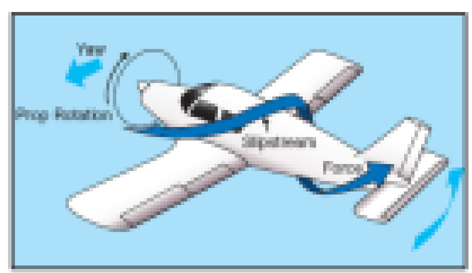
A. A stall can occur at any airspeed, attitude, or power setting, depending on the total factors affecting the aircraft

B. Airspeed & Power Settings
   - i. As mentioned above, a stall can occur at any airspeed
     - a. Low Speed and/or Low Power Setting
       - As airspeed decreases, AOA must be increased to maintain altitude
       - Eventually, an AOA is reached that results in the wing stalling because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
     - b. High Speed and/or High-Power Setting
       - If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate alteration of the flight path
         - a Since the AOA is suddenly increased while the flight path remains the same, the aircraft reaches the critical AOA at a speed much higher than the published stall speed
         - b More on load factors/accelerated stalls below
       - Depending on the aircraft, a higher power setting may help to reduce the stall speed and increase the lift on the wings
         - a Although the wing may be stalled, a higher power setting can provide increased lift due to the propeller airflow/prop wash moving over the wing roots
         - b More prominent in low wing aircraft where the propeller airflow moves directly over the wing
         - c This airflow also likely has a relatively low angle of attack
   - ii. Increased power at slow airspeeds and high angles of attack results in increased left turning tendencies
     - a. Anticipate considerable right rudder to maintain coordination

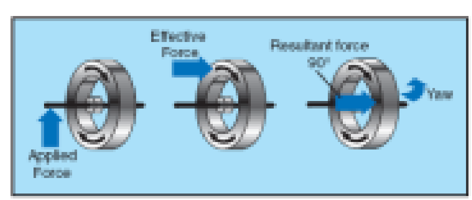
C. Yaw Effects
   - i. Increased power at slow airspeeds and high AOA (like stall recovery) aggravates left turning tendencies
     - a. Anticipate considerable right rudder to maintain coordination
   - ii. Torque Reaction



     - a. Newton's 3rd Law – Every action has an equal/opposite reaction
       - The engine/propeller rotate one way; an equal force tries to rotate the plane the opposite direction
     - b. Although torque reaction is more of a rolling tendency than a yaw effect, it does contribute to the left turning tendencies
     - c. Be mindful, especially at high power settings
   - iii. Corkscrew/Slipstream Effect



     - a. The high-speed rotation of the propeller sends air in a corkscrew rotation to the rear of the aircraft
       - Air strikes the left side of the vertical stabilizer, pushing the nose left
     - b. At high propeller speeds/low forward speeds (like in a stall recovery) the rotation is compact & pronounced
       - Strong force on the vertical tail causing yaw to the left
       - As forward speed increases, the spiral elongates and becomes less effective
     - c. Countered with coordinate rudder and aileron
   - iv. Gyroscopic Action



     - a. Gyroscopes are based on two fundamental principles:
       - Rigidity in space (not applicable to this discussion)
       - Precession - Resultant action of a spinning rotor when a force is applied to its rim
         - a When a force is applied, it takes effect 90° ahead of,

and in the direction of turn

1. Causes a pitch/yaw moment or combo of the two depending on where applied

b Any yawing around the vertical axis results in a pitching moment

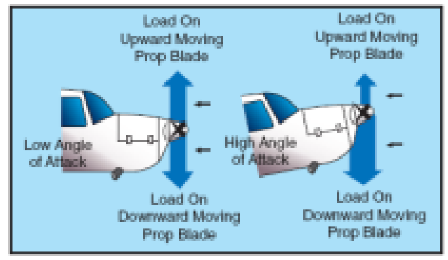
c Any pitching around the lateral axis results in a yawing moment

b. In relation to power-off stalls, lifting the nose results in a yaw to the left
- An aggressive nose raise and/or power push can result in the nose rising rapidly
- Correction is made with elevator and rudder pressures to maintain pitch attitude & coordination

v. Asymmetric Loading (P-Factor)

a. When flying at a high AOA, the bite of the down moving blade is greater than the up moving blade
- Moves the center of thrust to the right of the propeller disc area causing a yaw to the left

b. In relation to stalls, high power at a high AOA increases P-factor
- Compensated for with right rudder



vi. Big Picture

a. Considerable right rudder is required to maintain coordination during a power-on stall recovery

b. If turning:
- A right turn requires even more right rudder
- A left turn requires less right rudder (still requires right rudder)

D. Configuration (Gear and Flaps)

i. Flaps

a. Reduce the stall speed of an aircraft
- Most flaps increase the camber of the wing and change the chord line, producing more lift
  - a The nose of the aircraft is lowered to prevent ballooning
  - b Generally, the lowered nose and additional lift assist in decreasing the stall speed (factors will vary based on aircraft/flap design)
- Note the differing speeds on the airspeed indicator (green arc vs white arc)

ii. Gear

a. The effects of gear can vary based on the aircraft design and characteristics

b. Gear extension increases drag and if not properly compensated for could lead to a stall
- Ex. Gear down and a low power setting, combined with increasing pitch to maintain altitude

E. Weight

i. As the weight of the aircraft is increased, the stall speed increases

a. Remember, to maintain altitude lift must equal weight

b. So, the greater the weight, the greater the lift required

c. A higher AOA is required to generate the lift (all other factors remaining the same)

d. The higher AOA puts the aircraft closer to the critical AOA; thus the aircraft will stall at a higher speed

ii. A lighter aircraft will stall at a slower airspeed

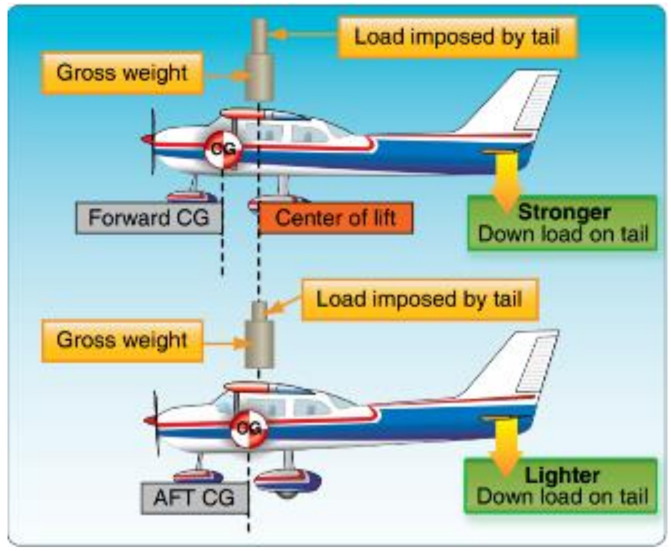
a. Same as above, but opposite. Less lift is required, and the AOA can be reduced (all other factors remaining the same), lowering the stall speed

F. Center of Gravity

i. Forward Center of Gravity (CG)

a. Increases the stall speed

b. A forward center of gravity has the same effect on stall speed as a heavier aircraft
- The farther forward the center of gravity moves, the higher the angle of attack has to be to compensate for the extra load imposed by the tail (see picture)



- Due to the higher AOA, the aircraft is closer to the critical AOA and therefore will stall at a higher speed

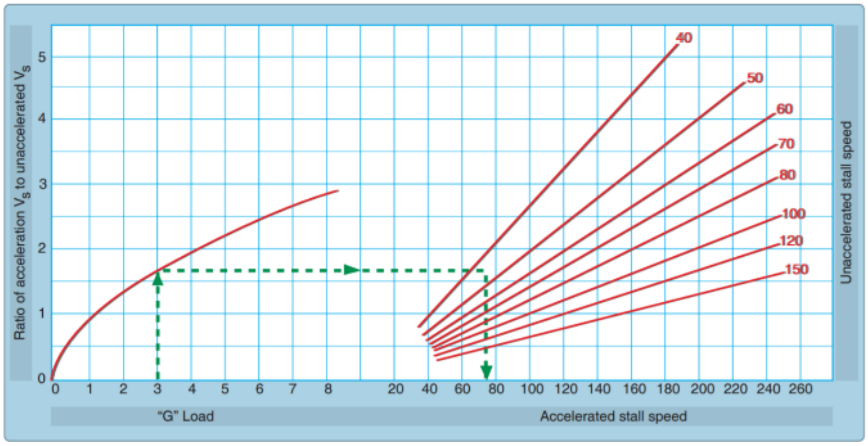
c. The aircraft is also more controllable due to the longer arm from the CG to the elevator, improving the stall recovery capabilities
   - Additionally, the farther forward the CG, the greater the tendency for the nose to pitch down
     - a Imagine it as more "nose heavy"

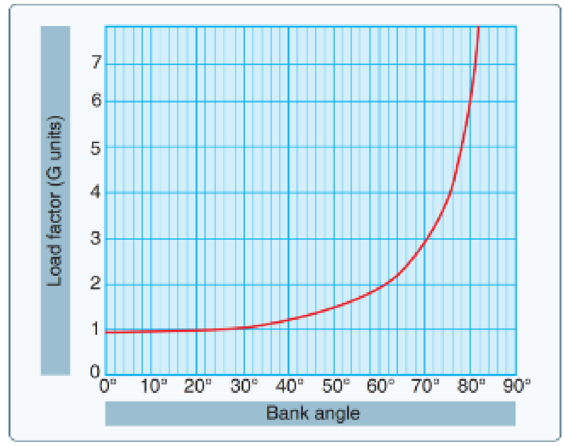
d. Worth noting:
   - The higher AOA and increased deflection of the stabilizer increases drag; thus the aircraft is slower for a given power setting

ii. Aft CG
   a. Decreases the stall speed
   b. An aft center of gravity has the same effect on stall speed as a lighter aircraft
      - The farther aft the CG, the lower the AOA has to be to compensate for the load imposed by the tail
      - Due to the lower AOA, the aircraft is farther from the critical AOA and will stall at a lower speed
   c. Although stall speed is lower, the aircraft is less controllable due to the shorter arm from CG to elevator
      - Shortened arm produces less force making recovery more difficult
      - As the CG moves aft, recovery from a stall becomes progressively more difficult
      - Additionally, the farther aft the CG, the less tendency for the nose to pitch down on its own
        - a Imagine it as more "tail heavy"
   d. Worth noting:
      - The lower AOA and less downward deflection of the stabilizer reduces drag; thus the aircraft is faster for a given power setting

G. Load Factor
   i. Increased load factor increases the stall speed
   ii. Load factor is the ratio of the total load acting on the aircraft to the gross weight of the aircraft
      a. Expressed in terms of Gs
   iii. Any increase in the load factor increases the stall speed
      a. The stall speed increases in proportion to the square root of the load factor
      b. When an aircraft is stalled at a higher than indicated air speed due to excessive maneuvering loads, it is called an accelerated maneuver stall
   iv. Pulling out of a steep descent, steep turns, aggressive control inputs, etc. Anything that puts Gs on the aircraft can increase the load factor and therefore the stall speed

H. Bank Angle & Load Factor
   i. Increased bank angle increases the stall speed
   ii. Increased load factors are a characteristic of all banked turns
   iii. Tremendous loads are imposed as bank is increased beyond 45°
      a. At a 60° bank, a load factor of 2 Gs is imposed on the airplane structure
      b. At a 70° bank, a load factor of approximately 3 Gs is placed on the airplane
      c. At approx. 63° of bank the stall speed is increased by approximately ½





I. Snow, Ice, and Frost
  i. Increase the stall speed
  ii. Snow, ice, and frost disrupt the smooth flow of air over the wing causing the boundary layer to separate at an angle of attack lower than the critical angle of attack
    a. To make matters worse, lift is greatly reduced due to the disrupted air, and if ice accumulates, the weight of the aircraft is increased
      - More lift is required due to the added weight, but less lift is available due to the ice
    b. As little as .8 millimeters of ice on the upper wing increases drag and reduces lift by 25%

3. RM: **Possible Situations for an Unintentional Power-On Stall** AI.X.D.K4, AI.X.D.R1

A. High power, high pitch situations
B. Generally associated with takeoff, climb, and go arounds. Most hazardous of these situations are likely:
  i. Short field takeoff – higher pitch for the aggressive climb. The aircraft is closer to the stall speed
  ii. Go Around – changing configuration, changing pitch attitude, changing power. May be significant nose up trim. Distractions can include radio calls, traffic, etc. A lot to keep up with
C. Improper airspeed control in high power, high pitch, or similar situations
  i. Distractions, disorientation, windshear, poor region of reversed command understanding & control, etc.
D. Maintain a consistent scan and use standard operating procedures/pitch & power settings

4. Power-On Stalls AI.X.D.K1

A. Differences - Considerably louder and steeper than a power-off stall
B. Entry
  i. *Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
  ii. Clearing the Area
  iii. Select an altitude - Must be able to recover prior to 1,500' AGL
  iv. *Takeoff Configuration: Takeoff Flaps (Can be practiced clean as well)
  v. Note the Heading (bug the heading)
C. Getting into the Straight-Ahead Stall
  i. *Reduce power to slow to normal lift off speed (V_R - 44 knots) while maintaining altitude
    a. Visually - The nose will pitch above the horizon, use a cloud, or other reference to maintain direction
  ii. *At V_R, increase power to 2200 RPM and maintain a climb attitude (12°-15°) until the stall occurs
    a. The nose will have a tendency to continue to pitch up and yaw to the left
      - Establish and maintain the desired pitch attitude
        a As airspeed decreases, controls become less effective, increase back pressure to maintain pitch
      - With the wings level, maintain coordination/heading with sufficient right rudder
        a Add right rudder when applying power to counter the left turning tendencies
        b As airspeed decreases, and the rudder becomes less effective, increase right rudder pressure to

maintain coordination

- Visual references should be primary during the maneuver, but back them up with the instruments

b. Just like in slow flight, use smooth movements to control the aircraft, nothing jerky

c. Larger control inputs will be necessary as the aircraft slows as the controls become less effective

D. Getting into the Turning Stall

i. In a climbing turn, the same procedures apply as a straight-ahead stall, except a specified bank angle is maintained (the Airplane Flying Handbook mentions 15-20^{o} of bank)

ii. When power is applied and the aircraft pitched for the climb, establish the desired bank angle

iii. Aileron pressure must be continually adjusted to keep the bank constant

a. Opposite aileron will likely be necessary to maintain the bank angle - overbanking tendency

- Overbanking Tendency:
  - a The slower the airspeed, the smaller the turn radius
    1. As airspeed slows in a turning stall, the radius of the turn continues to decrease
  - b The smaller the radius of the turn, the greater the difference in distance traveled between the outer and inner wing
  - c Because the outer wing is traveling a further distance in the same amount of time (it's going faster than the inner wing), it is generating more lift. This leads to the overbanking tendency
  - d Opposite aileron is required to counter the overbanking tendency

iv. Maintain coordination throughout the maneuver

a. This is especially important in a turning, power on stall due to the increased chance of a spin

v. Anticipate the overbanking tendency

vi. Increase control pressure as the aircraft slows and controls become less effective

E. Recognizing the Stall AI.X.D.K3

i. Announce the onset of the stall

a. Stall Warning Horn

b. Reduced Control Effectiveness

c. Buffet

d. Stall

ii. Sight

a. Nose high attitude of the airplane

- Especially high in a power on stall

iii. Sound

a. Stall warning horn

b. Loss of RPM is noticeable due to the increased load on the propeller

c. Noise will tend to decrease with airspeed and the slower flow of air around the aircraft

iv. Kinesthesia (the sensing of movements by feel, "seat of the pants" sensations, your "spidey sense")

a. In visual flight, the physical sensation of changes in direction is an important indicator to the trained pilot

b. If properly developed, it can warn the pilot of an impending stall

- The pilot can recognize when something doesn't feel right
- Not reliable in IMC, without visual references to verify the feelings

v. Feel

a. Control pressures become progressively less effective (mushy)

- The lag between control movements and response of the aircraft become greater

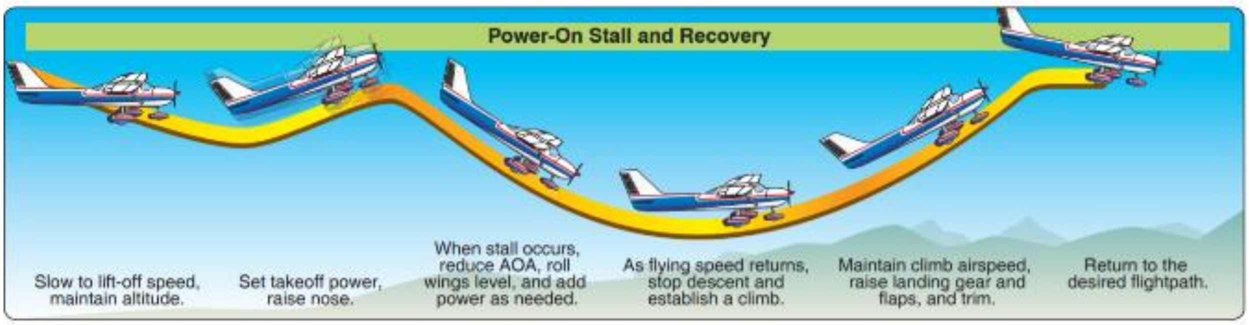
b. Buffeting, uncontrollable pitching or vibrations just before the stall

- Caused by turbulent air flowing from the wings, over the fuselage and to the horizontal stabilizer

c. Leaning back

vi. Aircraft Specific
   a. Note any aircraft specific designs, indicators, characteristics, etc.
vii. RM: Stall Warning Range & Limitations AI.X.D.R2
   a. Buffet: Tends to occur prior to the stall horn
      - Generally, an early indication of a stall
      - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
         a Design, attitude, configuration, etc. preventing turbulent air from the wings hitting the stab
   b. Stall Horn
      - Designed to provide warning of an approaching stall and time for stall recovery
      - Per 23.207
         a Clear/distinct stall warning with flaps & gear in any normal position, in straight and turning flight
         b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
         c Must provide the pilot time to take action to avert the stall
   c. Stall indications and horns have different operational ranges and limitations
      - Reference the POH for specific information
      - Ex: Uncoordinated flight may inhibit airflow at the stall indicator
      - Situations where one wing (without the indicator) stalls first

F. RM: Recovery (RM: Stall recovery procedure) AI.X.D.K5, AI.X.D.R4



A. Basics: Disconnect, Pitch, Roll, Thrust, Stabilize, Configure (perform each step as appropriate)
   i. Disconnect the autopilot
   ii. Pitch nose down
      a. Pitch attitude/angle of attack must be decreased positively and immediately
      b. The cause of any stall is an excessive angle of attack, decreasing the angle of attack is crucial
      c. Be familiar with the control pressures required for your aircraft
         - Excessive pitch down can result in excessive altitude loss
         - Insufficient pitch down will not break the stall
         - If the nose is trimmed up, additional pressure will be required to break the stall
            a If able/necessary, trim the nose down during the recovery
   iii. Roll wings level
      a. Regain/maintain directional control with coordinated aileron and rudder
      b. Reorients the lift vector vertical for a more effective recovery and climb
      c. Do not attempt to level the wings prior to reducing angle of attack
         - A stalled wing can roll the opposite direction of aileron input (more info below)
   iv. Thrust/power as necessary
      a. Stalls can occur at high/low power settings and airspeeds so adjust power as required
      b. In general, maximum allowable power should be applied to increase airspeed and help increase airflow over the wings, assisting in stall recovery
      - Power is not essential to stall recovery, reducing the AOA is the only way of recovering

- Right rudder will be required to maintain coordination/heading
  - a Use outside references - add rudder to keep the nose from yawing across the horizon

c. Stabilize/establish the desired flight path
- Establish a climb at the desired airspeed V_Y (or V_X if necessary)

d. Configure
- Once in a climb, configure/retract the flaps and landing gear as necessary

v. Ailerons and Recovery

a. Most general aviation aircraft are designed to stall progressively outward from the wing root
- The wings are designed in this manner so that aileron control will be available at high AOA and give the airplane more stable stalling characteristics
- During the recovery, the return of lift begins at the tips and progresses towards the roots
  - a Thus, ailerons can be used to level the wings

b. If the wing is fully stalled (ailerons included), using the ailerons can aggravate the stall
- EX: If the right wing dropped, and excessive aileron was applied to raise the wing, the right wing (aileron down) would produce a greater AOA and more (induced) drag
  - a Increasing the AOA on an already stalled wing will aggravate the stall on that wing
  - b The increase in drag and aggravated stall on the low wing will yaw the aircraft in the direction of that wing and could result in a spin

vi. Rudder and Recovery

a. The primary cause of an inadvertent spin is exceeding the critical AOA while applying excessive or insufficient rudder and, to a lesser extent, aileron.
- Therefore, it is important that the rudder be used properly during the entry and recovery

b. The primary use of rudder is to counteract any tendency of the airplane to yaw or slip

c. One wing will often drop in a power-on stall
- Maintaining directional control and coordinated flight with the rudder is vital in avoiding a spin

5. Common Errors (AFH 5-21) AI.X.D.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.
M. Excessive airspeed buildup during recovery.
N. Losing situational awareness and failing to return to the desired flightpath or follow ATC instructions.

6. RM: **Hazards**

A. Stall Warning during Normal Operation AI.X.D.R3

i. Recover

ii. The first thought is not how and why is this happening, the first reaction is to recover/fix the problem

a. When safe, then you can figure out how it happened

B. Secondary Stalls AI.X.D.R5

i. Occurs after recovery from a preceding stall

a. Pilot does not sufficiently reduce AOA or attempts to recover using power only
ii. More likely to occur at low altitude, where the natural impulse is to pull up abruptly
iii. Perform the stall recovery procedure again
iv. Prevent secondary stalls with proper recovery procedures (Push, Roll, Thrust, Stabilize)

C. Accelerated Stalls AI.X.D.R5
i. Higher G loads increase the stall speed (Ex. Steep turns, aggressive pull up)
ii. Use smooth, controlled inputs
iii. Recover at the first indication

D. Elevator Trim Stalls AI.X.D.R5
i. Effects of adding full power for a go-around with nose-up trim for the approach without maintaining control
ii. Preventing Elevator Trim Stalls
a. Use smooth power applications
b. Anticipate and overcome the trim forces pitching the nose up, and maintain positive control
c. Rough trim the airplane (fine tune later) to remove the excessive nose up pitch

E. Cross-Controlled Stalls
i. Uncoordinated aileron and rudder in opposite directions can lead to a cross-controlled stall
ii. Often associated with the traffic pattern, and especially hazardous at low altitudes
a. Ex. Overshooting final and using rudder to “help the turn” with opposite aileron to maintain 30° bank
iii. May have little to no warning of the impending stall
iv. Release the crossed-controls and recover
v. Prevent cross-controlled stalls by maintaining coordination

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

F. X. RM Concepts – Environmental Elements AI.X.D.R6
G. X. RM Concepts – Collision Hazards AI.X.D.R7
H. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.D.R8

Conclusion:
Brief review of the main points
Exceeding the critical angle of attack causes a stall. A stall can occur at any airspeed, in any attitude, or at any power setting, depending on the total number of factors affecting the airplane.

Private Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500’ AGL (ASEL) or 3,000’ AGL (AMEL).
2. Set power (as assigned by the evaluator) to no less than 65 percent available power.
3. Maintain heading, ±10° in straight flight; maintain specified bank not to exceed 20°, ±10°, in turning flight.

Commercial Pilot ACS Skills Standards
1. Select an altitude that will allow the Task to be completed no lower than 1,500’ AGL (ASEL) or 3,000’ AGL (AMEL).
2. Set power (as assigned by the evaluator) to no less than 65% available power.
3. Maintain heading, ±10° in straight flight; maintain specified bank not to exceed 20°, ±10°, in turning flight.

X.E. Accelerated Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of accelerated stalls and develop the ability to recognize the stalls and take prompt, effective recovery action.
Key Elements	1. Excessive Maneuvering Loads 2. Unusual Stall Attitudes 3. Normal Recovery
Elements	1. Accelerated Stall Aerodynamics 2. Various Factors & their Effect on Stall Speed 3. Accelerated Stall Situations 4. Accelerated Stalls 5. Common Errors 6. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands situations in which an accelerated stall is possible and can recognize and effectively recover from the stall.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Stalling during a steep turn, or in a level, possibly even nose low attitude? Didn't think that could happen?

Overview

Review Objectives and Elements/Key ideas

What

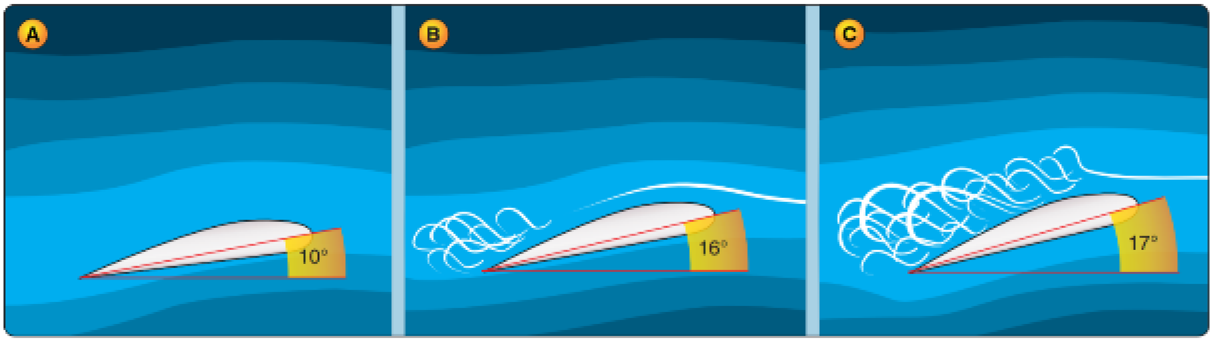
Stalls entered from flight situations that impose excessive maneuvering loads on the airplane. Situations such as steeps turns, pull-ups, or other abrupt changes in flightpath.

Why AI.X.E.K1

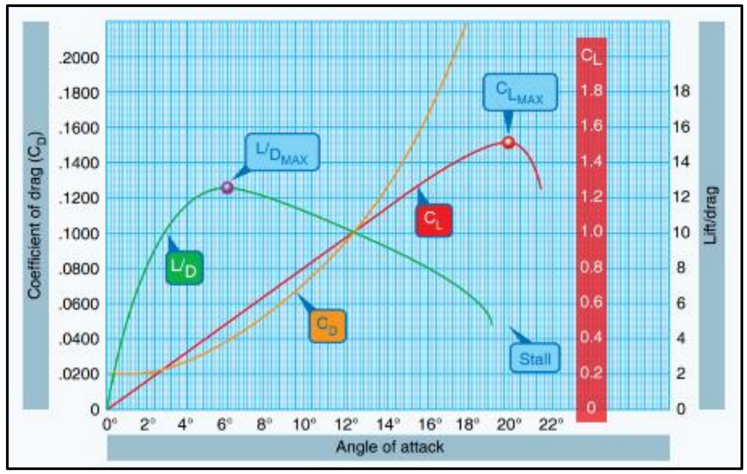
Stalls which result from abrupt maneuvers tend to be more rapid, or severe, than the unaccelerated stalls, and because they occur at higher-than-normal airspeeds, and/or at lower than anticipated pitch, they may be unexpected.

How:

1. **Accelerated Stall Aerodynamics** AI.X.E.K2
   A. Why an Aircraft Stalls
      i. Basically…
         a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
            - This happens when the wing exceeds its critical angle of attack (AOA)
               a The critical AOA varies, but is usually around 15-20^{o} in a general aviation aircraft
               b Remember, AOA is the angle between the chord line of the wing and the relative wind
            - A stall can occur at any airspeed, in any attitude, with any power setting
      ii. More Specifically…
         a. Airflow Over the Wing
            - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in graphic below)
            - As AOA increases, the airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in graphic below)
            - As AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift, and leading to airflow separation and a stall (C in graphic below)
               a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of the airflow from the wing's surface



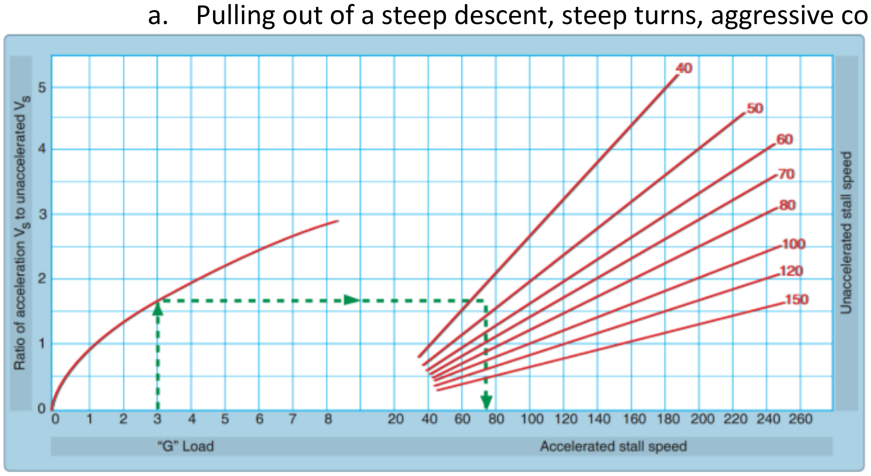
a. The Critical Angle of Attack/C_{LMAX}
  - The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
  - C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
    - a Determined by wind tunnel tests and based on airfoil design and AOA
  - Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly

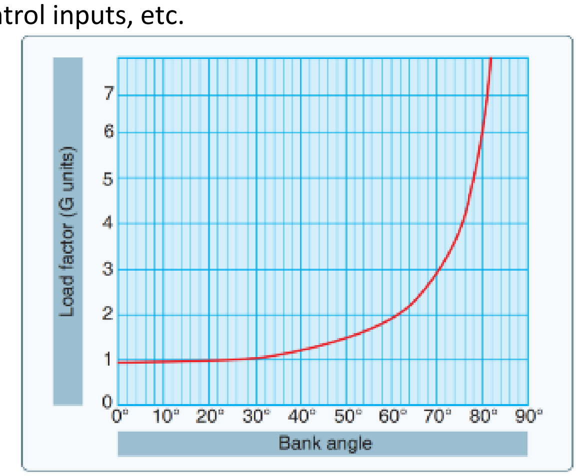


B. Stall Characteristics
  i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips
    a. By having the root stall first, aileron effectiveness is maintained at the wingtips, maintaining controllability of the aircraft
  ii. Various design can be used to accomplish this:
    a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
      - Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
      - These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip
    b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than it would otherwise stall

C. What is an Accelerated Stall?
  i. At the same gross weight, configuration, CG location, power setting, and environmental conditions, a given plane will stall at the same indicated airspeed provided the plane is at 1G (steady state unaccelerated flight)
  ii. However, the plane can also stall at a higher indicated airspeed when subject to a load factor > 1G
    a. Ex. Turning, pulling up, or other abrupt changes to the flight path
  iii. Stalls encountered when the G-load, or load factor, exceeds 1G are called Accelerated Stalls

D. Increased Load Factor Increases Stall Speed
  i. Load factor is the ratio of the total load acting on the aircraft to the gross weight of the aircraft
    a. Expressed in terms of Gs
  ii. The stall speed increases in proportion to the square root of the load factor
    a. An aircraft with a stall speed of 50 knots can be stalled at 100 knots by inducing a load factor of 4Gs
  iii. Anything that puts Gs on the aircraft increases the load factor and therefore the stall speed
    a. Pulling out of a steep descent, steep turns, aggressive control inputs, etc.





iv. Bank Angle and Load Factor
  a. Increased load factors are a characteristic of all turns
  b. Tremendous loads are imposed on an airplane as the bank is increased beyond 45°
    - At a 60° bank, a load factor of 2 Gs is imposed on the airplane structure
    - At approx. 63° of bank the stall speed is increased by approximately ½
  c. Example: Entering a turn, increased back pressure is required to maintain altitude
    - Another way of saying this is that the wings must produce additional lift to maintain altitude (increased load factor)
      a Remember, in a turn the vertical component of lift is split into a horizontal & vertical component
    - The additional lift comes from added back pressure which increases AOA
      a The flight path/relative wind remain the same, while pitch is increased leading to a higher AOA
    - If at any time during the turn the AOA becomes excessive, the aircraft will stall

v. Aggressive Pull ups and Load Factor
  a. Recovering too aggressively from a steep descent can quickly and significantly increase load factor, and AOA can quickly exceed critical AOA
  b. Ex. If an aircraft is in a high-speed dive, and the pilot pulls back sharply on the elevator, gravity and centrifugal force prevent an immediate change to the flight path
    - AOA changes abruptly from quite low to very high, but even though the nose has been raised, the aircraft continues its trajectory downward for some amount of time (load factor is increased)
    - Since AOA is suddenly increased while the flight path remains the same, the aircraft can reach the critical AOA at a speed much higher than the published stall speed

C. Hazards of Accelerated Stalls
  i. Significant load factor increases can be imposed when pulling out of steep dives or in steep turns
    a. Can result in structural damage at high airspeeds
    b. Mitigation: Stay below V_A & use smooth control inputs to limit G-forces
  ii. Accelerated stalls tend to occur at higher airspeeds and to be more aggressive due to the higher airspeeds
    a. Can catch a pilot off guard
    b. A prolonged accelerated stall may result in a spin or other departure from controlled flight
    c. Mitigation: Understand accelerated stalls, and recognize & recover promptly

2. Various Factors & their Effect on Stall Speed AI.X.E.K2

A. A stall can occur at any airspeed, attitude, or power setting, depending on the total factors affecting the aircraft

B. Power Settings
  i. Low Speed and/or Low Power Setting
    a. As airspeed decreases, AOA must be increased to maintain altitude
    b. Eventually, an AOA is reached that results in the wing stalling because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
    c. Increased load factor only exacerbates the slow, high AOA aircraft
  ii. High Speed and/or High-Power Setting
    a. As discussed above
    b. Depending on the aircraft, a higher power setting may reduce stall speed and increase lift on the wings
      - Although the wing may be stalled, a higher power setting can provide increased lift due to the propeller airflow/prop wash moving over the wing roots
      - More prominent in low wing aircraft where the propeller airflow moves directly over the wing
      - This airflow also likely has a relatively low angle of attack

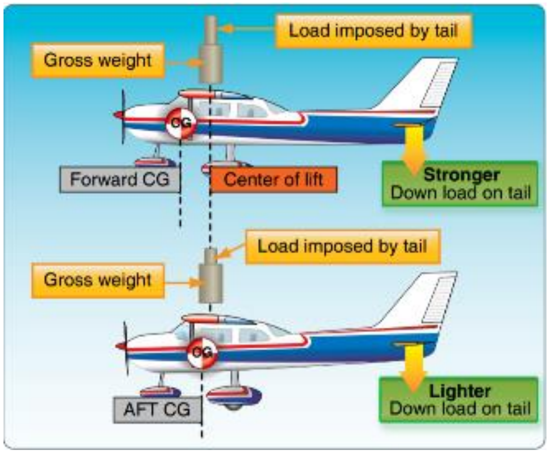
C. Yaw Effects
  i. Uncoordinated flight combined with high load factors/accelerated stalls can quickly lead to a spin
  ii. The higher stall speed, lower than anticipated pitch attitude, and aggressive stall can catch a pilot off guard

a. If uncoordinated this can lead to a spin

D. Configuration
   i. Flaps
      a. Reduce the stall speed of an aircraft
         - Most flaps increase the camber of the wing and change the chord line, producing more lift
            a The nose of the aircraft is lowered to prevent ballooning
            b Generally, the lowered nose and additional lift assist in decreasing the stall speed (factors will vary based on aircraft/flap design)
         - Note the differing speeds on the airspeed indicator (green arc vs white arc)
      b. Flaps do not protect from an accelerated stall
         - Lower designed g-loads in flap configurations could lead to failure/damage

E. Weight
   i. As the weight of the aircraft is increased, the stall speed increases
      a. Remember, to maintain altitude lift must equal weight
      b. So, the greater the weight, the greater the lift required
      c. A higher AOA is required to generate the lift (all other factors remaining the same)
      d. The higher AOA puts the aircraft closer to the critical AOA; thus the aircraft will stall at a higher speed
   ii. A lighter aircraft will stall at a slower airspeed
      a. Same as above, but opposite. Less lift is required, and the AOA can be reduced (all other factors remaining the same), lowering the stall speed

F. Center of Gravity
   i. Forward Center of Gravity (CG)
      a. Increases the stall speed
      b. A forward center of gravity has the same effect on stall speed as a heavier aircraft
         - The farther forward the CG moves, the higher the AOA must be to compensate for the extra load imposed by the tail (see picture)
         - Due to the higher AOA, the aircraft is closer to the critical AOA and therefore will stall at a higher speed



      c. The aircraft is also more controllable due to the longer arm from the CG to the elevator, improving the stall recovery capabilities
         - Additionally, the farther forward the CG, the greater the tendency for the nose to pitch down
            a Imagine it as more "nose heavy"
      d. Worth noting:
         - The higher AOA and increased deflection of the stabilizer increases drag; thus, the aircraft is slower for a given power setting
   ii. Aft CG
      a. Decreases the stall speed
      b. An aft center of gravity has the same effect on stall speed as a lighter aircraft
         - The farther aft the CG, the lower the AOA has to be to compensate for the load imposed by the tail
         - Due to the lower AOA, the aircraft is farther from the critical AOA and will stall at a lower speed
      c. Although stall speed is lower, the aircraft is less controllable due to the shorter arm from CG to elevator
         - Shortened arm produces less force making recovery more difficult
         - As the CG moves aft, recovery from a stall becomes progressively more difficult
         - Additionally, the farther aft the CG, the less tendency for the nose to pitch down on its own

a Imagine it as more "tail heavy"

d. Worth noting:
- The lower AOA and less downward deflection of the stabilizer reduces drag; thus the aircraft is faster for a given power setting

e. by approximately ½

G. Snow, Ice, and Frost
i. Increase the stall speed
ii. Snow, ice and frost disrupt the smooth flow of air over the wing causing the boundary layer to separate at an angle of attack lower than the critical angle of attack
a. To make matters worse, lift is greatly reduced due to the disrupted air, and if ice accumulates, the weight of the aircraft is increased
- More lift is required due to the added weight, but less lift is available due to the ice

b. As little as .8 millimeters of ice on the upper wing increases drag and reduces lift by 25%

3. RM: **Accelerated Stall Situations** AI.X.E.K4, AI.X.E.R1

A. Steep, aggressive pull ups, or other abrupt changes in the aircraft's flightpath
i. Basically, anything that increases G-loading on the aircraft

B. Steep turns

C. Stall and spin recoveries, especially when close to the ground

D. Use smooth control inputs, ensure sufficient airspeed for higher G maneuvers like steep turns

4. Accelerated Stalls AI.X.E.K1

A. Pre-Maneuver
i. *Checklist
a. Fuel Pump ON
b. Mixture RICH
c. Lights ON
d. Gauges GREEN

ii. Clearing Turns

iii. At a Safe Altitude
a. Recover no lower than 3,000' AGL

iv. Setup
a. Two methods for performing an accelerated stall per the Airplane Flying Handbook
- Below V_A, roll into 45° of bank and smoothly increase back pressure to induce a stall (most common)
- Roll into a 45° bank above V_A, and after the airspeed reaches V_A, increase back pressure

b. Configure as required
- Never practice accelerated stalls with flaps extended due to the lower design G-load limitations in that configuration

B. Performing
i. Establish the desired flight attitude
a. At or Below V_A
- The airplane will stall before the limit load factor can be exceeded

b. From straight and level, roll into a steep, level turn (About 45°)

ii. Then smoothly, firmly, and progressively increase the AOA until a stall occurs (at/below V_A)
a. Increases wing loading, decrease airspeed, and the centrifugal force will push the pilot into the seat

C. Recognizing the Stall AI.X.E.K3
i. Buffet, stall warning horn will indicate an impending stall
a. The nose high attitude and reduction in noise as the aircraft slows doesn't occur in accelerated stalls

ii. The airplane typically stalls during a coordinated steep turn exactly as it does from straight and level flight,

except the buffet tends to be sharper, and the pitching and rolling actions tend to be more sudden
- If coordinated - Both wings stall simultaneously, just like straight and level
- If slipping - Tends to roll rapidly toward the outside of the turn (Outside wing stalls 1st)
- If skidding - Tends to roll rapidly toward the inside of the turn (Inside wing stalls 1st)

iii. High or increasing descent rate

iv. Aircraft Specific
   a. Note any aircraft specific designs, indicators, characteristics, etc.

v. RM: Stall Warning Range & Limitations AI.X.E.R2
   a. Buffet: Tends to occur prior to the stall horn
      - Generally, an early indication of a stall
      - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
         a Design, attitude, configuration, etc. preventing turbulent air from the wings hitting the stab
   b. Stall Horn
      - Designed to provide warning of an approaching stall and time for stall recovery
      - Per 23.207
         a Clear/distinct stall warning with flaps & gear in any normal position, in straight and turning flight
         b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
         c Must provide the pilot time to take action to avert the stall
   c. Stall indications and horns have different operational ranges and limitations
      - Reference the POH for specific information
      - Ex: Uncoordinated flight may inhibit airflow at the stall indicator
         a Situations where one wing (without the indicator) stalls first

D. RM: Recovery: Disconnect, Pitch, Roll, Thrust, Stabilize, Configure AI.X.E.K5, AI.X.E.R4
   Perform each step as appropriate
   i. Disconnect: the autopilot is likely already disconnected
   ii. Pitch: The elevator pressure should be released
      a. Reduce the AOA and eliminate the stall warning
   iii. Roll: Use coordinated aileron and rudder pressures to level the wings
   iv. Thrust: Adjust power as necessary
      a. If a high airspeed already exists, additional power may not be necessary
      b. Power may even need to be reduced depending on the airspeed and attitude
      c. If a spin were to develop, power should be taken to idle
   v. Stabilize: Return to the desired flight path
   vi. Configure: Likely no changes applicable, but establish the desired configuration

5. Common Errors (AFH 5-21) AI.X.E.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.

M. Excessive airspeed buildup during recovery.
   i. Losing situational awareness and failing to return to the desired flightpath or follow ATC instructions.

6. RM: **Hazards**

A. Stall Warning during Normal Operation — AI.X.E.R3
   i. Recover
   ii. The first thought is not how and why is this happening, the first reaction is to recover/fix the problem
      a. When safe, then you can figure out how it happened

B. Secondary Stalls — AI.X.E.R5
   i. Occurs after recovery from a preceding stall
      a. Pilot does not sufficiently reduce AOA or attempts to recover using power only
   ii. More likely to occur at low altitude, where the natural impulse is to pull up abruptly
   iii. Perform the stall recovery procedure again
   iv. Prevent secondary stalls with proper recovery procedures (Push, Roll, Thrust, Stabilize)

C. Cross-Controlled Stalls — AI.X.E.R5
   i. Uncoordinated aileron and rudder in opposite directions can lead to a cross-controlled stall
   ii. Often associated with the traffic pattern, and especially hazardous at low altitudes
      a. Ex. Overshooting final and using rudder to “help the turn” with opposite aileron to maintain 30° bank
   iii. May have little to no warning of the impending stall
   iv. Release the crossed-controls and recover
   v. Prevent cross-controlled stalls by maintaining coordination

D. Spins — AI.X.E.R5
   i. Stall + Yaw (or uncoordinated flight)
      a. Recover at the first sign of a stall
      b. Maintain coordination to prevent a spin
   ii. In the case a spin develops, recover using PARE
      a. Power idle, Ailerons neutral, Rudder opposite the spin, Elevator forward

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E. X. RM Concepts – Environmental Elements — AI.X.E.R6
F. X. RM Concepts – Collision Hazards — AI.X.E.R7
G. X. RM Concepts – Distractions, SA & Disorientation, & Task Management — AI.X.E.R8

Conclusion:
Brief review of the main points
It is important that the pilot be able to determine the stall characteristics of the airplane being flown and develop the ability to instinctively recover at the onset of a stall at other than normal stall speeds or flight attitudes.

Commercial Pilot ACS Skills Standards

1. Establish a coordinated 45° bank, increasing elevator back pressure until an impending stall is reached.
2. Acknowledge the cue(s) and recover at the first indication of an impending stall (e.g., aircraft buffet, stall horn, etc.).

X.F. Cross-Controlled Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner understands the dynamics of a cross-controlled stall and can recognize situations which could lead to a cross-controlled stall. The learner also should be able to safely and effectively demonstrate and properly recover from a cross-controlled stall.
Key Elements	1. Too much rudder can hurt us 2. Little or no warning of a stall 3. Intuitive reactions are dangerous
Elements	1. Cross-Controlled Stall Aerodynamics 2. Recognizing Cross-Controlled Stalls 3. Cross-Controlled Stalls 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
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IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The lesson is complete when the learner understands the unique requirements for a cross-controlled stall and can confidently recognize and recover from a cross-controlled situation.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Situation intro below

Overview

Review Objectives and Elements/Key ideas

What

This type of stall occurs with the controls crossed – aileron pressure applied in one direction and rudder pressure in the opposite direction.

Why

It is imperative that this type of stall not occur during an actual approach to landing since recovery may be impossible prior to ground contact due to the low altitude. During traffic pattern operations, any conditions that result in overshooting the turn from base leg to final approach dramatically increase the possibility of an unintentional accelerated stall if the airplane is in a cross-controlled condition.

How:

Very interesting read on cross-controlled stalls from APS (Aviation Performance Solutions)

1. **Cross-Controlled Stall Aerodynamics** AI.X.F.K1, AI.X.F.K2
   A. Situation
      i. Left turn from base to final with an overshooting wind pushing the aircraft past the centerline and potentially into the final approach of a parallel runway
      ii. The pilot rolls to 30º of bank, the safe bank limit in the pattern, but it isn't enough to prevent the overshoot
      iii. To avoid the overshoot, and help the turn, the pilot adds left rudder, causing the aircraft to roll left, and the nose to drop. To compensate, the pilot inputs right aileron (opposite direction of the left rudder – the aircraft is now cross controlled), and raises the nose with back elevator pressure
         a. The additional left roll is caused by the left rudder input, and the difference in lift between the two wings. When the nose swings left, the right wing swings forward and the left wing swings backward. The right wing is accelerated and the left decelerated. Lift is increased on the right wing, resulting in left bank. Right aileron is required to maintain the 30º banked turn
         b. The nose drops due to the uncoordinated flight and additional drag. Raising the nose brings the AOA closer to the critical AOA
      iv. Still not enough to prevent the overshoot, the pilot adds additional left rudder with the same outcome. More right aileron is required to maintain the bank angle, and backpressure is added to maintain the pitch
      v. Suddenly, the aircraft rolls sharply left, inverted (or even into a spin)
      vi. The pilot instinctually responds with right aileron and back elevator pressure to "fix" the situation
         a. Right aileron to roll the aircraft back over
         b. Back pressure to get away from the fast-approaching ground
      vii. Even with these inputs, the aircraft rolls further to the left and accelerates its descent to the ground
   B. Why did this happen?
      i. A cross controlled stall occurs when the critical AOA is exceeded with aileron pressure applied in one direction and rudder pressure in the opposite direction, causing uncoordinated flight
         a. A cross-control stall can lead to a violent roll toward the inside wing, and/or a spin

ii. Two Important Effects of the Excessive Rudder in the Turn (opposite aileron & back pressure)
  a. Opposite Aileron (creates the cross-controlled situation)
    - As the right wing accelerates, right aileron is necessary to maintain bank
    - Although the pilot can balance the difference in lift between the wings and maintain 30° of bank in the pattern, right aileron pressure increases AOA on the left wing, and decreases it on the right wing
      a Right aileron pressure results in an upward deflected aileron on the right and a downward deflected aileron on the left
        1. Deflected ailerons change the chord line and therefore the AOA of each wing
          a. The AOA on the left, inside wing (downward deflected aileron) increases
          b. The AOA on the right, outside wing (upward deflected aileron) decreases
      b The inside, low wing has a higher AOA than the outside, high wing
  b. Back Elevator Pressure (leads to the stall)
    - The nose drop, due to increasing drag, leads to increased back pressure
    - Increased back pressure to maintain the same flight path leads to an increased AOA
  c. Overall
    - The aircraft AOA has been increased with the added back pressure
    - The AOA of the left, inside wing is increased even further with the right aileron input

iii. The Stall and the Reaction to the Stall
  a. At the point of the stall, the inside wing (left, in this case), has a higher AOA and therefore stalls first
    - Suddenly, the low wing has considerably less lift than the high wing and the aircraft rolls rapidly in the direction of the low wing – often inverted, if not corrected quickly enough
  b. The pilot may react by applying even more aileron to roll right side up (in this case, right aileron)
    - More opposite aileron further increases the AOA on the left wing, deepening the stall and rolling the aircraft further left
    - As the ground approaches quickly, instinct is to pull up and climb, but when inverted and stalled, pulling up only sends the aircraft to the ground faster
      a The stall gets even deeper
  c. Stall + Yaw = Spin. The aircraft could very easily end up in a low altitude spin

C. The Moral of the Story
  i. Stay coordinated, especially low to the ground
  ii. In the case of an overshoot, or a cross controlled situation, go around and avoid the risk

D. RM: Limitations AI.X.F.R4
  i. Chapter 2 of the POH - Reference any aircraft limitations associated with cross-controlled stalls

2. Recognizing Cross-Controlled Stalls AI.X.F.K2, AI.X.F.K3

A. Understand the conditions that can lead to a cross-controlled stall

B. Be alert for these conditions, especially at low altitudes
  i. Uncoordinated flight with the rudder and aileron in opposite directions
  ii. Most likely to occur in the pattern during an overshooting turn from base to final

3. Cross-Controlled Stalls AI.X.F.K4

A. Safe Altitude
  i. Before demonstrating the stall, it is extremely important to be at a safe altitude
    a. This is because of the extreme nose down attitude and loss of altitude that could occur
  ii. Per the ACS: Select an entry altitude that allows the Task to be completed no lower than 3,000' AGL

B. *Pre-Maneuver Checklist
  i. Fuel Pump ON
  ii. Mixture FULL RICH
  iii. Lights ON

   iv. Gauges GREEN
C. Clear the Area
   i. Perform clearing turns
D. Set Up
   i. Gear down (if retractable)
   ii. Close the throttle
   iii. Do not extend flaps because of the possibility of the airplane's limitations being exceeded
   iv. Maintain altitude until reaching normal glide speed
      a. Re-trim the plane
      b. Remember, at a reduced airspeed, or at gliding speed, the aircraft is closer to a stall:
         - Aircraft will be slower and is therefore closer to the stall speed
         - To maintain altitude, pitch attitude must be increased so the aircraft is closer to the critical AOA
E. Performing
   i. Roll into a medium-bank turn
      a. This should simulate a final approach turn that would overshoot the centerline of the runway
   ii. During the turn, excessive rudder pressure should be applied in the direction of the turn but the bank held constant by applying opposite aileron pressure
   iii. At the same time, increase back elevator pressure to keep the nose from lowering
   iv. All these control pressures should be increased until the airplane stalls
      a. Due to the sideslip, and abnormal airflow, the airplane may stall without warning
         - Depending on the location of the stall warning horn, it may or may not warn the pilot of the stall
         - Due to the sideslip, and the fuselage blocking a large portion of airflow over the elevator, the buffet may not be felt until very late (right before the stall), if at all
F. RM: Recovery - Disconnect, Pitch, Roll, Thrust, Stabilize, Configure (perform each step as appropriate) AI.X.F.K5, AI.X.F.R1
   i. Recovery must be made before the airplane enters an abnormal attitude
      a. The pilot must be able to recognize when this stall is imminent and must take immediate action to prevent a completely stalled condition, and/or a spin
   ii. When the stall occurs:
      a. Disconnect: Likely not applicable in this situation
      b. Pitch: Apply nose down pressure to reduce AOA and eliminate the stall warning
         - In most aircraft, releasing the control forces will break the stall; additional nose down pressure may be required
      c. Roll: Remove the excessive rudder, and level the wings
         - Do not attempt to correct with opposite aileron - this will increase the roll, possibly to an inverted condition
         - Return to coordinated flight
      d. Thrust: Add power as necessary
      e. Stabilize: Return to the desired flight path
      f. Configure: Likely not applicable, but establish the configuration required
G. Spin Recovery
   i. This maneuver can result in a spin
   ii. Recovery
      a. Power - Idle
      b. Ailerons - Neutral
      c. Rudder - Opposite
      d. Elevator - Briskly forward

- Break the stall

e. Rudder - Relaxed

f. Elevator - To pull out of stall

H. Bottom Line: Stay coordinated to avoid a cross-controlled stall!

4. Common Errors (AFH 5-21) AI.X.F.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.
M. Excessive airspeed buildup during recovery.
N. Losing situational awareness and failing to return to the desired flightpath or follow ATC instructions.

5. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. X. RM Concepts – Environmental Elements AI.X.F.R2
B. X. RM Concepts – Collision Hazards AI.X.F.R3
C. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.F.R5

Conclusion:

Brief review of the main points

It is imperative that this type of stall not occur during an actual approach to landing, since recovery may be impossible prior to ground contact due to the low altitude. During traffic pattern operations, any conditions that result in overshooting the turn from base leg to final approach dramatically increases the possibility of an unintentional accelerated stall while the airplane is in a cross-control condition. If overshooting, do not try to correct with rudder, instead initiate a go-around and try again.

X.G. Elevator Trim Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of elevator trim stalls and their application in executing a safe go-around. The learner understands the inherent danger involved when positive control of the airplane is not maintained, especially close to the ground.
Key Elements	1. Maintain Positive Control 2. Anticipate Attitude Changes 3. Do Not Stall in a Go-Around
Elements	1. Stall Aerodynamics 2. Elevator Trim Stall Situations 3. Elevator Trim Stall Procedures 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can safely recover from an elevator trim stall and properly and safely perform a go-around procedure, correcting for any unintentional changes in airplane attitude, without stalling.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Applying full power with too much nose up trim (as in an approach to land) can have dire results if we don't know how to deal with it.

Overview

Review Objectives and Elements/Key ideas

What

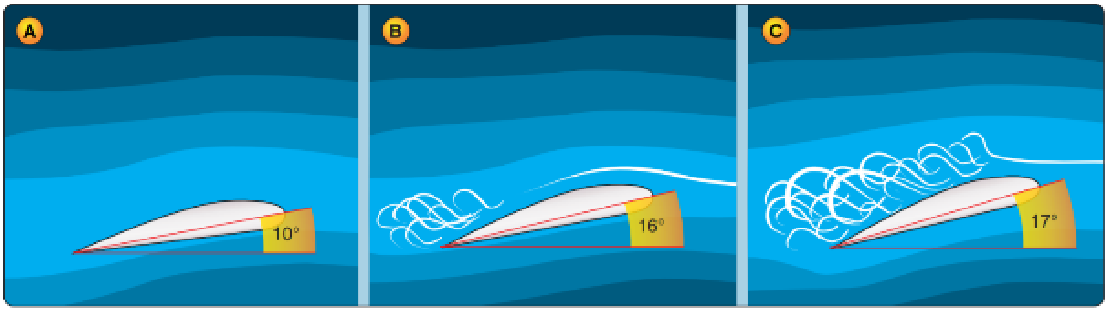
The elevator trim stall maneuver shows what can happen when full power is applied to an aircraft with nose-up trim and positive control of the airplane is not maintained.

Why

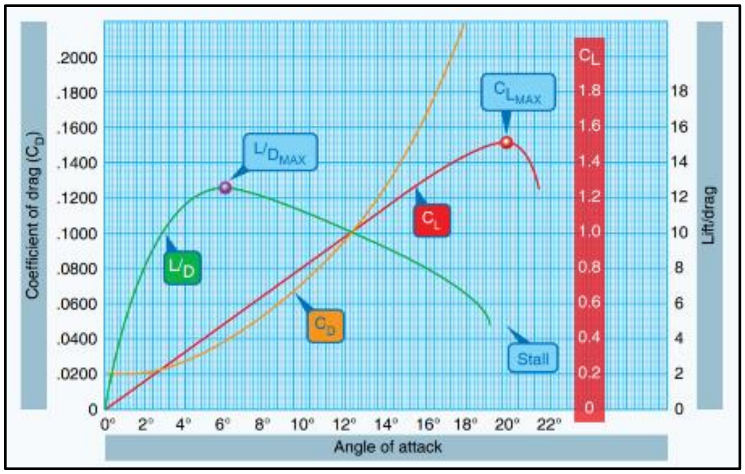
A situation like this could occur during a go-around procedure or immediately after takeoff. The objective is to show the importance of making smooth power applications, overcoming strong trim forces, maintaining positive control of the airplane, and using proper trim techniques. It's imperative a stall doesn't occur during an actual go-around.

How:

1. **Stall Aerodynamics** AI.X.G.K1
   A. Why an Aircraft Stalls
      i. Basically…
         a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
            - This happens when the wing exceeds its critical angle of attack (AOA)
               a The critical AOA varies between aircraft, but is usually around 15-20º in a GA aircraft
               b Remember, AOA is the angle between the chord line of the wing and the relative wind
            - A stall can occur at any airspeed, in any attitude, with any power setting
      ii. More Specifically…
         a. Airflow Over the Wing
            - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in the graphic)
            - As AOA increases, the airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in the graphic below)
            - As the AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift and leading to airflow separation and a stall (C in the graphic)
               a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of the airflow from the wing's surface



b. The Critical Angle of Attack/C_{LMAX}
- The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
- C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
  - a Determined by wind tunnel tests and based on airfoil design and AOA
- Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly



B. Stall Characteristics

i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips

a. By having the root stall first, aileron effectiveness is maintained at the wingtips, maintaining controllability of the aircraft

ii. Various design can be used to accomplish this:

a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
- Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
- These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip

b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than otherwise

C. Specific to the Elevator Trim Stall

i. In the event of a go around, as maximum power is applied, the nose will rise sharply and turn left

a. The combined effect of nose high trim, and increased prop wash over the tail and elevator make the nose rise sharply

b. Torque and the left turning tendencies make the aircraft yaw/turn to the left

c. If uncontrolled, the excessive nose-up pitch can result in a stall

d. If uncorrected, the uncoordinated left turn/yaw can lead to a spin

D. RM: Limitations AI.X.G.R4

i. Chapter 2 of the POH - Reference any aircraft limitations associated with elevator trim stalls

2. Elevator Trim Stall Situations AI.X.G.K2

A. Primarily used to demonstrate a go-around without maintaining control of the aircraft

i. Basically, any situation where the aircraft is trimmed nose high and considerable power is added

B. Situations include:

i. Normal landing approach followed by a go around

ii. Simulated forced landing approach and the following recovery

iii. Immediately after takeoff with the trim still set for the landing approach (nose high trim)

iv. Runaway autopilot

3. Elevator Trim Stall Procedures

A. Entry AI.X.G.K4

i. Pre-Maneuver

a. *Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN

b. Select an altitude – Per the ACS: Task must be completed no lower than 3,000' AGL

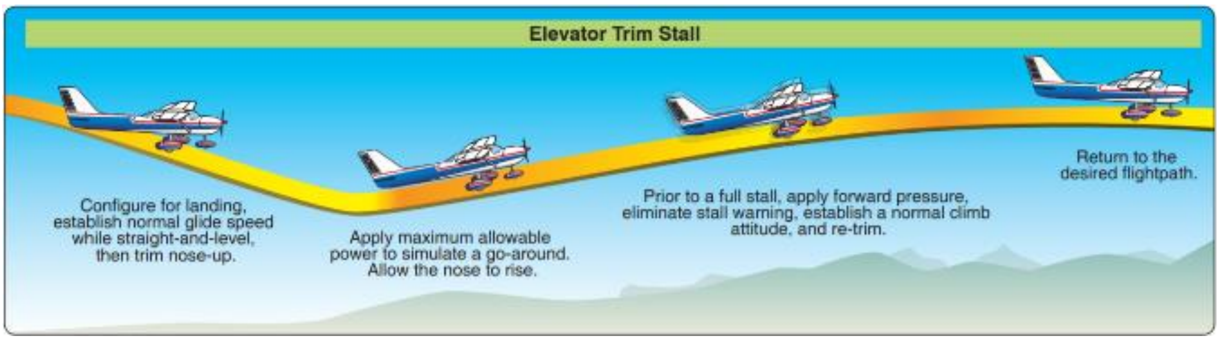
c. Clear the Area

d. Note the heading (bug the heading if necessary) for reference purposes

ii. Setup

a. Slowly retard the throttle while maintaining altitude
b. As airspeed decreases, configure the aircraft for landing
    - Lower the gear, if applicable, and extend landing flaps
c. Once configured, close the throttle, and maintain altitude until airspeed approaches normal glide speed
d. Once established on speed, trim the aircraft the maintain the glide speed
e. CE: Failure to establish selected configuration prior to entry
    - Nose up trim is necessary for demonstration of the maneuver
    - If safe, full nose up trim can be demonstrated to show the student the worst-case scenario

B. Performing the Elevator Trim Stall



i. Smoothly advance the power to the maximum allowable (as would be done in a go-around)
  a. The nose will rise sharply and turn to the left
    - With the throttle fully advanced, the pitch attitude quickly increases above the normal climb attitude and if left uncontrolled, will lead to a stall and potentially a spin
      - a This could be especially hazardous when close to the ground
    - Remember, this is a demonstration, so the student needs to see the effects of power/nose high trim
      - a Allow time for the student to see the hazards without compromising safety
  b. This scenario highlights the importance of maintaining positive control of the aircraft and understanding the effects of nose high trim and high-power settings
    - Instruct the student to anticipate and correct for the excessive pitch with forward pressure, and correct for the left turning tendencies with right rudder
    - Fly the aircraft, don't let the aircraft fly you
      - a As the nose rises aggressively/abnormally, correct the condition before it becomes an issue
      - b Power and right rudder always go together - if the nose yaws left, add right rudder to correct

ii. Recognize the stall is imminent AI.X.G.K3
  a. Stall warning horn and buffeting
  b. Rapid pitch up, combined with rapid loss of airspeed

C. RM: Recovery - Disconnect, Pitch, Roll, Thrust, Stabilize, Configure AI.X.G.K5, AI.X.G.R1
(perform each step as appropriate)

i. Disconnect the autopilot (this may be the reason for the excessive trim)
ii. Pitch: Sufficient forward pressure must be applied to return the airplane to normal climbing attitude
  a. This will take considerably more forward pressure than normal to overcome the nose high trim
  b. Since an elevator trim stall is likely to occur near the ground, overly excessive forward pressure could lead to impacting the ground
    - Set the pitch attitude required to break the stall and establish a normal climb
  c. If necessary, rough trim the airplane to relieve pressure
iii. Roll: Coordinated roll as necessary to maintain wings level
iv. Thrust: As required (likely max power if it's not already there)
v. Stabilize: While holding the airplane in a normal attitude, trim should be relieved, and the normal go-around

and level-off procedures completed

vi. Configure: As you would for a normal go around

vii. If a full stall occurs, recovery will require significant nose-down pitch to reduce the AOA below the critical AOA, as well as a corresponding significant loss of altitude

  a. Important that a full stall not occur during a go-around as there may not be enough altitude to recover

viii. Often instinct is to undo the action that caused the problem

  a. In this case, adding power created the excessively nose high, left yaw situation
  b. Although it might be somewhat helpful, taking the power back to idle could lead to other problems, namely:
     - A significant loss of airspeed while close to the ground
     - The inability to climb while close to the ground
        a This could be further complicated if the pilot decides to add back pressure to climb away from the approach ground, only to accelerate the descent

4. Common Errors (AFH 5-21) AI.X.G.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.
M. Excessive airspeed buildup during recovery.
N. Losing situational awareness and failing to return to the desired flightpath or follow ATC instructions.

5. RM: **Hazards** (see X. RM Concepts for details)

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. X. RM Concepts – Environmental Elements AI.X.G.R2
B. X. RM Concepts – Collision Hazards AI.X.G.R3
C. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.G.R5

Conclusion:

Brief review of the main points

It is very important that a pilot understands the elevator trim stall hazard associated with go-arounds. By understanding the risk involved if positive control of the airplane's attitude is not maintained future flights will be considerably safer.

X.H. Secondary Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Stall and Spin Awareness Training (AC 61-67), POH/AFM

Objectives	The learner develops knowledge of the elements related to secondary stalls and the importance of an initial proper stall recovery.
Key Elements	1. Airspeed! 2. Increased Load Factor 3. More Pronounced Stall the 2nd Time
Elements	1. Stall Aerodynamics 2. Secondary Stall Situations 3. Secondary Stall Procedures 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands the importance of a properly performed stall recovery.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Fool me once shame on you. Fool me twice, shame on me. Stalling once isn't good. Stalling twice *really* isn't good.

Overview

Review Objectives and Elements/Key ideas

What

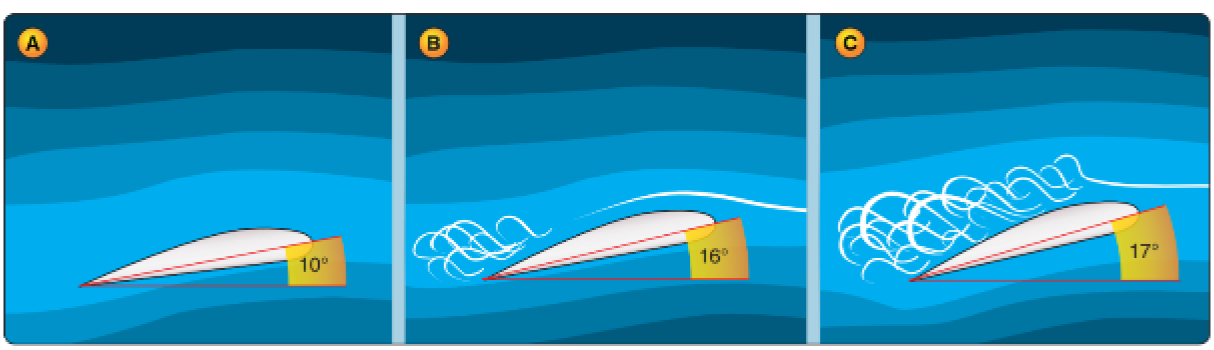
A secondary stall is a stall that occurs after a recovery from a preceding stall.

Why

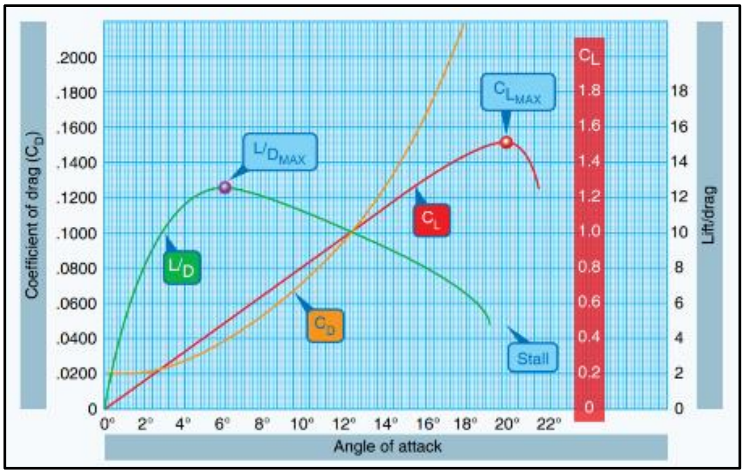
The loss of altitude associated with a single stall can be potentially hazardous. By stalling a second time while still recovering from the first stall, the altitude loss is amplified, and the second stall may be more aggressive. Learning the proper stall recognition and recovery procedures and seeing/demonstrating a secondary stall will allow the pilot to safely recover the first time and not aggravate the situation.

How:

1. **Stall Aerodynamics** AI.X.H.K1
    A. Why an Aircraft Stalls
        i. Basically…
            a. A stall occurs when the smooth airflow over the top of the wing is disrupted, and lift decreases rapidly
                - This happens when the wing exceeds its critical angle of attack (AOA)
                    a The critical AOA varies, but is usually around 15-20^{o} in a general aviation aircraft
                    b Remember, AOA is the angle between the chord line of the wing and the relative wind
                - A stall can occur at any airspeed, in any attitude, with any power setting
        ii. More Specifically…
            a. Airflow Over the Wing
                - A certain amount of lift is generated by the difference in pressure between the top and bottom of the wing. This lift is dependent on the smooth airflow over the top of the wing (A in graphic below)
                - As AOA increases, the airflow over the top of the wing cannot maintain the smooth flow and starts to burble and separate from the trailing edge (B in graphic below)
                - As AOA continues to increase, the separation point moves farther forward along the top of the wing hindering its ability to create lift, and leading to airflow separation and a stall (C in graphic below)
                    a Thus, a stall occurs due to a rapid decrease in lift caused by the separation of the airflow from the wing's surface



c. The Critical Angle of Attack/C_{LMAX}
   - The point at which the airflow separates and there is a rapid reduction in lift is the stalling AOA, or the critical AOA, or C_{LMAX} (the Max Coefficient of Lift)
   - C_L = Coefficient of Lift – A way to measure lift as it relates to AOA
     a Determined by wind tunnel tests and based on airfoil design and AOA
   - Any AOA beyond C_{LMAX} results in a stall and lift drops off rapidly



b. A stall can occur at any speed, attitude, or power setting
   - If at *ANY* time (low speed/high speed, high power/low power, straight/turning, etc.) the aircraft's AOA becomes excessive, the aircraft will stall

B. Stall Characteristics
   i. Most GA aircraft are designed to stall at the wing root first and then progress outward to the wing tips
      a. By having the root stall first, aileron effectiveness is maintained at the wingtips, maintaining controllability of the aircraft
   ii. Various design can be used to accomplish this:
      a. Twisting the wing to create a lower angle of attack at the wing tip compared to the wing root
         - Angle of Incidence – The angle of the chord line of the wing relative to the fuselage
         - These aircraft are designed with a higher angle of incidence near the wing root, leading to a lower angle of incidence at the wing tip
      b. Adding strips to the first 20-25% of the wing's leading edge to induce a stall earlier than it would otherwise stall

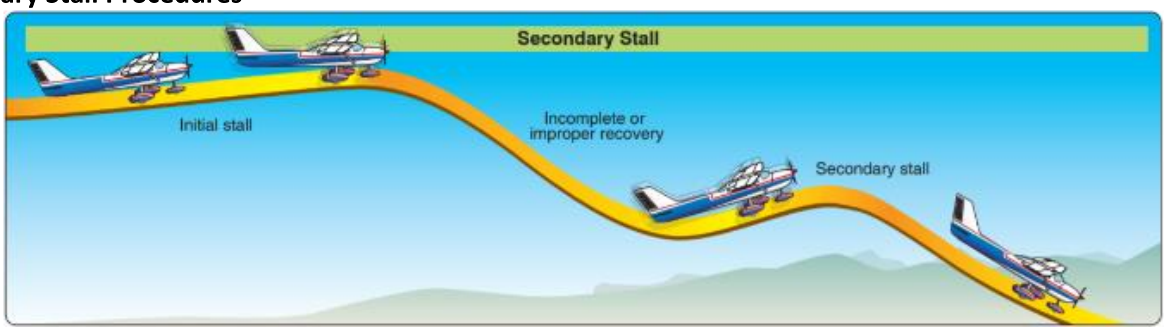
C. Specific to a Secondary Stall
   i. A secondary stall is typically caused by abrupt control inputs or attempting to return to the desired flight path too quickly exceeding the critical AOA a second time
      a. Secondary stall is often deeper and more aggressive than the first and can result in more altitude lost
         - The nose may drop farther, and yaw/roll more violently
      b. Attempting to recover too aggressively, recovering only with power (no pitch correction), or recovering before the stall has been broken can quickly lead to a secondary stall
   ii. Hazards Associated with a Secondary Stall
      a. Prolonged Recovery
         - It takes longer to recover from two stalls than one. If close to the ground and time and altitude are limited, the secondary stall may be the difference between hitting the ground and recovering
         - Startle Factor
           a Not only does it take longer, and more altitude, to recover from two stalls than one, but the startle factor and unexpected nature of the second stall could lead to an additional delay in recovering if the pilot isn't sure what is happening
      b. Additional Loads on the Aircraft
         - Aggressive pull-ups can impose additional loads, potentially damaging the aircraft
      c. Spin and/or Loss of Control
         - Because the secondary stall is often more aggressive and unexpected, there is a greater likelihood of it turning into a spin or loss of control

B. RM: Limitations AI.X.H.R4
   i. Chapter 2 of the POH - Reference any aircraft limitations associated with elevator trim stalls

2. Secondary Stall Situations AI.X.H.K2

A. Attempting to recover from a stall using only pitch
   i. Pitch & power are necessary to return to normal flight
   ii. Lowering pitch can break the stall, but without power and/or sufficient airspeed, raising the nose will quickly lead to another stall
B. Attempting to recover from a stall using power only
   i. Pitch must be used to recover from a stall, the AOA must be reduced
   ii. In most GA aircraft, adding power while maintaining the nose high stalled attitude will result in a second stall (power-on stall in this case)
C. A stall recovery close to the ground
   i. In the case the recovery must happen quickly (the aircraft is close to the ground), the pilot may prematurely raise the nose into a second stall
D. Abrupt, overaggressive control movements
   i. This may be the result of nerves, fear, etc.
   ii. Use smooth, controlled movements

3. Secondary Stall Procedures



A. Pre-Maneuver AI.X.H.K4
   i. *Checklist
      a. Fuel Pump ON
      b. Mixture RICH
      c. Lights ON
      d. Gauges GREEN
   ii. Perform clearing turns
   iii. Select a safe altitude (ACS: Task to be completed no lower than 3,000’ AGL)
   iv. Setup
      a. Setup and configure for a power on or power off stall, as required
      b. Once configured, perform the initial stall
B. Getting into the Secondary Stall
   i. Upon reaching the first stall, reduce the angle of attack, then abruptly pull back on the controls
      a. Do not exceed V_A
C. Recognizing the Stall AI.X.H.K3
   i. Similar to a normal stall, but often times more aggressive/pronounced
      a. The stall warning horn will sound again
      b. Buffeting rapidly returns
      c. Excessive back pressure
      d. Controls are “mushy”, loss of control effectiveness
      e. Nose down pitch, high sink rate

f. Yaw
- Depends on the stall characteristics, power on vs power off stall, and the pilot's coordination

D. RM: Recovery: Disconnect, Pitch, Roll, Thrust, Stabilize, Configure AI.X.H.K5, AI.X.H.R1
(perform each step as appropriate)
   i. When a secondary stall occurs, the pilot should again perform the stall recovery procedures
   ii. Pitch: Apply nose down elevator pressure as required
      a. Properly reduce the AOA to break the stall
   iii. Roll: Coordinated roll to maintain or return to wings level
   iv. Thrust: Apply maximum power
      a. Maintain coordination (correct for the left turning tendencies with right rudder)
      b. Reestablish airspeed and airflow over the wing roots (low wing aircraft)
   v. Stabilize: When sufficient airspeed has been regained, the airplane can be returned to straight and level flight or established in a climb at (V_X or V_Y)
      a. Because the stall is more aggressive the second time around, the recovery may have to be more aggressive (greater nose down pitch to break the stall)
   vi. Configure: Once stabilized, establish the desired configuration based on the phase of flight

4. Common Errors (AFH 5-21) AI.X.H.K6

A. Failure to adequately clear the area.
B. Over-reliance on the airspeed indicator and slip-skid indicator while excluding other cues after recovery.
C. Inability to recognize an impending stall condition.
D. Failure to prevent a full stall during the conduct of impending stalls, or recovering too early on a full stall
E. Failure to maintain a constant bank angle during turning stalls.
F. Failure to maintain proper coordination with the rudder throughout the stall and recovery.
G. Not disconnecting the wing leveler or autopilot, if equipped, prior to reducing AOA.
H. Recovery is attempted without recognizing the importance of pitch control and AOA
I. Not holding nose down controls until the stall warning is eliminated, or excessive forward pressure (negative Gs)
J. Pilot attempts to level the wings and/or recover with power before reducing AOA.
K. Failure to roll wings level after AOA reduction and stall warning is eliminated.
L. Inadvertent accelerated stall by pulling too fast on entry, & inadvertent secondary stall during recovery.
M. Excessive airspeed buildup during recovery.
N. Losing situational awareness and failing to return to the desired flightpath or follow ATC instructions.

5. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. X. RM Concepts – Environmental Elements AI.X.H.R2
B. X. RM Concepts – Collision Hazards AI.X.H.R3
C. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.H.R5

Conclusion:

Brief review of the main points

Properly recover from the stall the first time. The second stall likely will be more pronounced and is worth avoiding.

X.I. Spin Awareness & Spins

References: 14 CFR Part 23, Type Certificate Data Sheet; Stall and Spin Awareness Training (AC 61-67), Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of the elements related to spins. The learner will learn how to recognize a spin, prevent a spin, and in the case of a spin, apply proper recovery procedures.
Key Elements	1. Stall + Yaw = Spin 2. Brisk and Positive Recovery 3. Ensure Spins are Approved
Elements	1. Spins & Anxiety 2. Spin Aerodynamics 3. Various Factors & Spins 4. Spin Situations 5. Recognizing Potential Spins 6. Intentional Spins 7. Spin Procedures 8. Common Errors 9. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the factors involved in creating and maintaining a spin and is competent in the process to recover from a spin.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Who WANTS to do a spin? Most people fear spins but understanding them will help in avoiding them and remove some of the fear.

Overview

Review Objectives and Elements/Key ideas

What

A spin is an aggravated stall that results in what is termed "autorotation," wherein the airplane follows a downward corkscrew path.

Why

An understanding of spins and the proper procedures to recover from them is necessary for safety. Understanding spins also increases confidence and reduces the anxiety associated with spins.

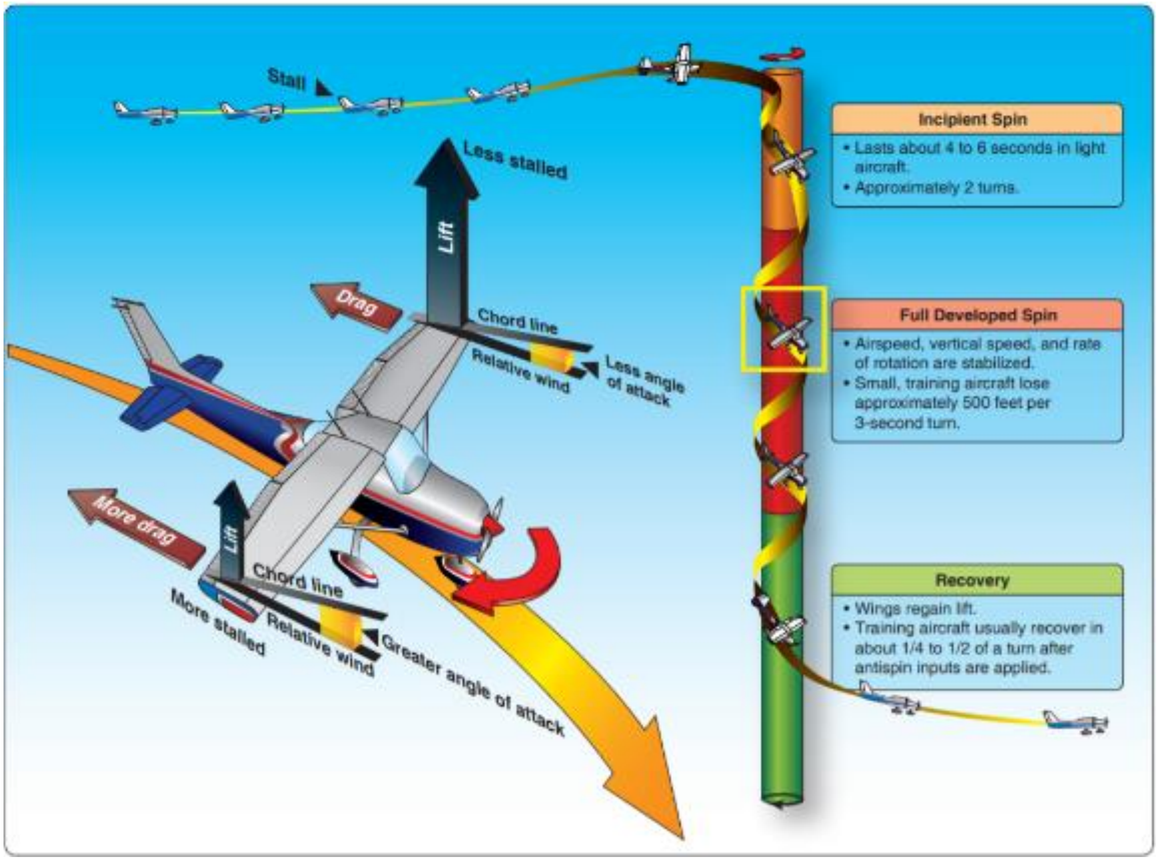
How:

1. **Spins & Anxiety** AI.X.I.K1, AI.X.I.K5
   A. Spins are scary
      i. A common perception to those unfamiliar with aviation is that a spin is a death sentence
      ii. They're scary even to a lot of pilots, BUT we're going to set you up for success with knowledge and training
         a. To get into a spin, you have to stall the aircraft
         b. Through your training, the intent is that you never unintentionally encounter a stall, but in the case that you do, you're confident and capable of recovering
         c. From there, the intent is that you're so well trained that even if you do unintentionally encounter a stall, you never encounter a spin
         d. And, in the unlikely event that the first 2 lines of defense fail, you will know how to recover from a spin
   B. Knowledge and training can remove the anxiety and make you a far safer and competent pilot
2. **Spin Aerodynamics** AI.X.I.K3
   A. Requirements for a Spin
      i. A spin occurs when the wings exceed their critical AOA (stall) with a sideslip, or yaw, acting on the airplane
         a. There are two requirements for a spin:
            - A stall
            - Yaw
               a Can be for any reason (rudder, adverse yaw, engine/prop effects, wake turbulence, etc.)
               b The yaw can occur at or beyond the actual point of stall
   B. Basically…
      i. In a spin, the inboard, low wing is more stalled than the outboard wing, which creates an autorotation, or rolling, yawing, and pitching motion around the vertical axis
   C. Specifically…
      i. When the aircraft stalls, one wing drops (the wing will drop in the direction of the yaw)
         a. Although both wings are stalled…
            - The wing that drops has an increasing angle of attack (more stalled)
               a Lift decreases and drag increases on this wing

- And the rising wing has a decreasing AOA (less stalled)
  - a Lift increases and drag decreases on this wing

ii. The autorotation results from the unequal angle of attack on the airplane's wings
   a. The difference in lift between the wings results in the rolling action
   b. The difference in drag between the wings results in the yawing action

iii. The load factor during a spin varies with the spin characteristics of each aircraft but is usually found to be slightly above the 1G of level flight. There are two reasons for this:
   a. Airspeed in a spin is very low, usually within 2 knots of the unaccelerated stall speed
   b. An aircraft pivots, rather than turns, while it is in a spin



D. 4 Phases of a Spin

i. Entry Phase
   a. The pilot intentionally or accidentally provides the elements for the spin (stall + yaw)

ii. Incipient Phase
   a. Occurs from the time the aircraft stalls and starts rotating to the time the spin has fully developed
      - Take approximately 2-4 turns for most aircraft
      - The aerodynamic and inertial forces have not yet balanced
   b. Indications
      - Indicated airspeed will generally stabilize at a low and constant airspeed
      - The airplane in the turn indicator will indicate the direction of the turn
        - a Keep in mind that the slip/skid ball is unreliable when spinning

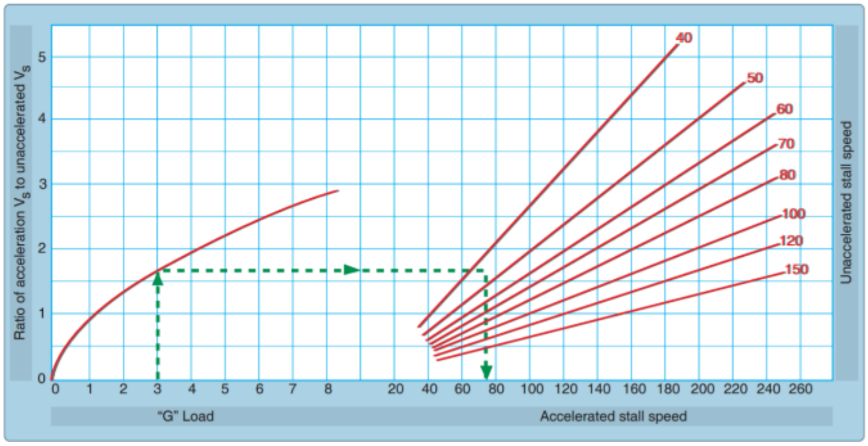
iii. Developed Phase
   a. Occurs when the airplane's angular rotation rate, airspeed, and vertical speed are stabilized in a flightpath that is nearly vertical
      - The spin is in equilibrium – the airplane's attitude, angles, and self-sustaining motions about the

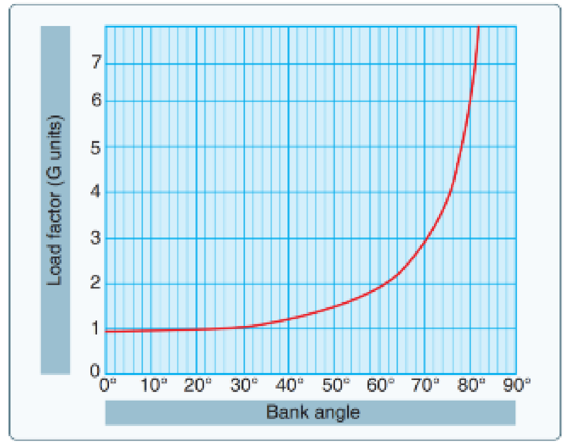
vertical axis are constant or repetitive, or nearly so

iv. Recovery Phase
   a. Occurs when rotation ceases, and the AOA of the wings is decreased below the critical AOA

3. **Various Factors & Spins** (Very similar to info in the Stall lessons since a stall leads to a spin) AI.X.I.K2
   A. A stall can occur at any airspeed, attitude, or power setting, depending on the total factors affecting the aircraft
   B. Power Settings
      i. Low Speed and/or Low Power Setting
         a. As airspeed decreases, AOA must be increased to maintain altitude
         b. Eventually, an AOA is reached that results in the wing stalling because the AOA has exceeded the critical angle and the airflow over the wing is disrupted
         c. Increased load factor only exacerbates the slow, high AOA aircraft
      ii. High Speed and/or High-Power Setting
         a. As discussed above
         b. Depending on the aircraft, a higher power setting may reduce stall speed and increase lift on the wings
            - Although the wing may be stalled, a higher power setting can provide increased lift due to the propeller airflow/prop wash moving over the wing roots
            - More prominent in low wing aircraft where the propeller airflow moves directly over the wing
            - This airflow also likely has a relatively low angle of attack
      iii. Increased power at slow airspeeds and high angles of attack results in increased left turning tendencies
         a. Anticipate considerable right rudder to maintain coordination
         b. Extremely important in preventing a spin
   C. Configuration
      i. Flaps
         a. Reduce the stall speed of an aircraft
            - Most flaps increase the camber of the wing and change the chord line, producing more lift
               a The nose is lowered to maintain altitude
               b Generally, the additional lift/lowered nose assist in decreasing the stall speed
                  1. Factors will vary based on aircraft/flap design
            - Note the differing speeds on the airspeed indicator (green arc vs white arc)
         b. Flaps do not protect from an accelerated stall
            - Lower designed g-loads in flap configurations could lead to failure/damage
      ii. Gear – the effects of gear can vary based on the aircraft design and characteristics
         a. Big picture, gear increases drag
   D. Load Factor
      i. Increased load factor increases the stall speed
      ii. Load factor is the ratio of the total load acting on the aircraft to the gross weight of the aircraft
         a. Expressed in terms of Gs
      iii. Any increase in the load factor increases the stall speed
         a. The stall speed increases in proportion to the square root of the load factor
         b. When an aircraft is stalled at a higher than indicated air speed due to excessive maneuvering loads, it is called an accelerated maneuver stall
      iv. Pulling out of a steep descent, steep turns, aggressive control inputs, etc. Anything that puts Gs on the aircraft can increase the load factor and therefore the stall speed
   E. Bank Angle & Load Factor
      i. Increased bank angle increases the stall speed
      ii. Increased load factors are a characteristic of all banked turns
      iii. Tremendous loads are imposed as bank is increased beyond 45°

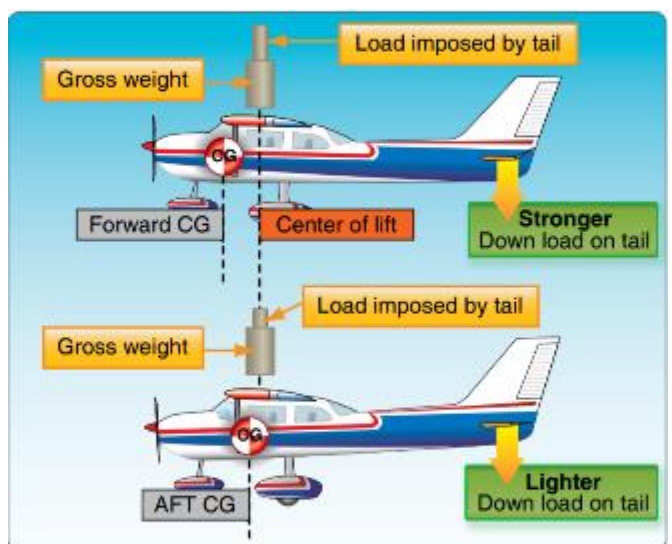
a. At a 60° bank, a load factor of 2 Gs is imposed on the airplane structure
b. At a 70° bank, a load factor of approximately 3 Gs is placed on the airplane
c. At approx. 63° of bank the stall speed is increased by approximately





F. Weight
  i. As the weight of the aircraft is increased, the stall speed increases
    a. Remember, to maintain altitude lift must equal weight
    b. So, the greater the weight, the greater the lift required
    c. A higher AOA is required to generate the lift (all other factors remaining the same)
    d. The higher AOA puts the aircraft closer to the critical AOA; thus, the aircraft will stall at a higher speed
  ii. A lighter aircraft will stall at a slower airspeed
    a. Same as above, but opposite. Less lift is required, and the AOA can be reduced (all other factors remaining the same), lowering the stall speed

G. Center of Gravity
  i. Forward Center of Gravity (CG)
    a. Increases the stall speed
    b. A forward center of gravity has the same effect on stall speed as a heavier aircraft
      - The farther forward the center of gravity moves, the higher the angle of attack has to be to compensate for the extra load imposed by the tail (see picture)
      - Due to the higher AOA, the aircraft is closer to the critical AOA and therefore will stall at a higher speed



    c. More controllable due to the longer arm from the CG to the elevator - improves stall recovery
      - The farther forward the CG, the greater the tendency for the nose to pitch down
        a Imagine it as more "nose heavy"
    d. Worth noting:
      - The higher AOA and increased deflection of the stabilizer increases drag; thus the aircraft is slower for a given power setting
  ii. Aft CG
    a. Decreases the stall speed
    b. An aft center of gravity has the same effect on stall speed as a lighter aircraft
      - The farther aft the CG, the lower the AOA has to be to compensate for the load imposed by the tail

            - Due to the lower AOA, the aircraft is farther from the critical AOA and will stall at a lower speed
        c. Although stall speed is lower, the aircraft is less controllable due to the shorter arm from CG to elevator
            - Shortened arm produces less force making recovery more difficult
            - As the CG moves aft, recovery from a stall becomes progressively more difficult
            - Additionally, the farther aft the CG, the less tendency for the nose to pitch down on its own
                a Imagine it as more "tail heavy"
        d. Worth noting:
            - The lower AOA and less downward deflection of the stabilizer reduces drag; thus, the aircraft is faster for a given power setting

H. Snow, Ice, and Frost
    i. Increase the stall speed
    ii. Snow, ice and frost disrupt the smooth flow of air over the wing causing the boundary layer to separate at an angle of attack lower than the critical angle of attack
        a. To make matters worse, lift is greatly reduced due to the disrupted air, and if ice accumulates, the weight of the aircraft is increased
            - More lift is required due to the added weight, but less lift is available due to the ice
        b. As little as .8 millimeters of ice on the upper wing increases drag and reduces lift by 25%

I. Yaw Effects
    i. Uncoordinated flight is what results in a spin
        a. Stall + Yaw = Spin
    ii. Maintaining directional control and preventing the nose from yawing before stall recovery is initiated is key to averting a spin
    iii. Pilot must apply the correct amount of rudder to keep the nose from yawing and the wings from banking

4. RM: Spin Situations AI.X.I.K7, AI.X.I.R1

A. A Stall + Yaw = Spin
    i. Any situation in which you have both a stall and yaw

B. During a go-around or short field takeoff
    i. High pitch attitude, high power setting, and low airspeed situations

C. Turn from base to final
    i. Cross controlled situation to avoid overshooting the runway without using excessive bank
    ii. The spin that occurs from cross controlling an aircraft usually results in rotation in the direction of the rudder being applied, regardless of which wingtip is raised

D. Sloppy stall recovery while practicing maneuvers

E. Unrecognized Stall Conditions
    i. RM: Stall Warning Range & Limitations AI.X.I.R2
        a. Buffet: Tends to occur prior to the stall horn
            - Generally, an early indication of a stall
            - May not always occur (Ex: Cross controlled stalls can occur with little to no warning)
                a Design, attitude, configuration, etc. preventing turbulent air from the wings hitting the stab
        b. Stall Horn
            - Designed to provide warning of an approaching stall and time for stall recovery
            - Per 23.207
                a Clear/distinct stall warning with flaps & gear in any normal position, in straight and turning flight
                b Warning must begin at least 5 knots above stall speed and continue until the stall occurs
                c Must provide the pilot time to take action to avert the stall
        c. Stall indications and horns have different operational ranges and limitations
            - Reference the POH for specific information

- Ex: Uncoordinated flight may inhibit airflow at the stall indicator
  - a Situations where one wing (without the indicator) stalls first

F. Recognizing Potential Spins AI.X.I.K10

i. Be aware of situations where a spin is most likely to occur

ii. Understand what causes a spin and avoid those situations

a. A spin is dependent on yawing during a stall – Maintain coordination

iii. Continued stall/spin recovery practice makes the pilot more competent in recognizing and avoiding a spin

5. Intentional Spins AI.X.I.K6

A. DO NOT intentionally spin an aircraft that is not authorized for spins

B. To determine if spins are approved check:

i. Airworthiness Category

ii. Type Certificate and Data Sheets

iii. AFM/POH – Limitations section

iv. Placard in the airplane stating, "No acrobatic maneuvers including spins approved"

C. In the case spins are approved, also check:

i. Weight and Balance limitations

ii. Recommended entry and recovery procedures

D. If the airplane is not certified, DO NOT attempt spins

i. Sometimes people will try to justify the maneuver

a. Technicality in the Airworthiness Standards

b. They say that the airplane was spin tested during certification

- Normal Category classification only requires that an airplane recover from a one-turn spin of not more than one additional turn or 3 seconds, whichever takes longer
  - a One 360° rotation does not provide a stabilized spin, therefore prolonged spins in that aircraft could be difficult or impossible to recover from

ii. 14 CFR Part 23

a. There are no requirements for investigation of controllability in a true spinning condition for normal category airplanes

- The one turn margin is a check of the controllability in a delayed stall (not spin) recovery
- Therefore, in airplanes placarded against spins, there is absolutely no assurance that recovery from a fully developed spin is possible

E. Weight and Balance Requirements

i. In airplanes approved for spins, compliance with weight and balance requirements is extremely important for safe performance and recovery from a spin maneuver

a. Even minor weight and balance changes can affect the airplane's spin recovery characteristics

- An aircraft that cleanly recovers from a prolonged spin with the CG at one position may fail completely to respond to normal recovery attempts when the CG is moved aft by one or two inches

b. An aircraft approved for spins in the utility category, but loaded in accordance with the normal category, may not recover from a spin that is allowed to progress beyond one turn

- It is common practice for aircraft designers to establish an aft CG limit that is within one inch of the Normal Category maximum, which allows normal recovery from a one-turn spin
- When certificating an aircraft in the utility category to permit intentional spins, the aft CG limit is usually established at a point several inches forward of that permissible for certification in the normal category

6. Spin Procedures AI.X.I.K1

A. Preflight

i. Perform a thorough preflight inspection with special emphasis on:

a. Excess or loose items that may affect weight, CG, and controllability
b. Within CG limitations
c. Slack or loose cables (especially rudder/elevator) could prevent recovery

B. Pre-Maneuver AI.X.I.K8
i. *Checklist - Fuel Pump ON; Mixture RICH; Lights ON; Gauges GREEN
ii. Clear the Area - Above and Below
iii. Altitude – CFI ACS: Select an entry altitude that allows the Task to be completed no lower than 4,000' AGL
a. Airplane Flying Handbook: Begin at an altitude high enough to complete recovery at or above 1,500' AGL
- First turn results in an altitude loss of about 1,000', each subsequent turn is about 500'

C. Maneuver
i. Entry Phase
a. Where the pilot provides the necessary elements for the spin (accidentally or intentionally)
b. Procedure (like a power off stall)
- Reduce power to idle while simultaneously raising the nose to a stalling pitch attitude
- As the stall approaches, smoothly apply full rudder in the direction of desired spin while applying full (to the limit) back elevator pressure
- Keep the ailerons neutral

c. Maintaining a Stabilized Spin AI.X.I.K9
- Maintain the above control inputs (yaw + stall)
  a Full back elevator pressure (stall)
  b Full rudder in the direction of the spin (yaw)
  c Neutral ailerons

d. Maintaining Orientation During a Spin AI.X.I.K11
- Select an outside reference point
- Use the turn coordinator
  a The turn coordinator deflects in the direction of the spin and is reliable
  b Gyroscopic Instruments may tumble and be misleading (heading indicator, attitude indicator)

ii. Incipient Phase
a. From the time the airplane stalls, and rotation starts until the spin has fully developed
- Incipient spins that are not allowed to develop into a steady-state spin are most often used in the initial spin training/recovery techniques
- May take to 2-4 turns for most aircraft
- The aerodynamic and inertial forces have not reached a balance
- Indicated airspeed should be near/below stall speed and the turn coordinator will indicate the direction of the spin

iii. Developed Phase
a. Occurs when the airplane's angular rotation rate, airspeed, and vertical speed are stabilized while in a flightpath that is nearly vertical
b. Aerodynamic forces and inertial forces are in balance, the spin is in equilibrium
c. Important to Note:
- Some training airplanes will not enter into the developed phase but could transition from the incipient phase to a spiral dive
  a In this case, the airplane will not be in equilibrium but instead will be accelerating and as a result, G load can rapidly increase
    1. In a spin, the airspeed does not accelerate

iv. RM: Recovery Phase (PARE Acronym – Power, Ailerons, Rudder, Elevator) AI.X.I.K4, AI.X.I.K12, AI.X.I.R3
a. Occurs when the AOA of the wings decrease below the critical AOA and autorotation slows

- Then, the nose steepens, and rotation stops – this phase may last ¼ of a turn to several turns

b. Note: Always follow the manufacturer's procedures. In the absence of the manufacturer's procedures, the recovery procedures below are recommended in the Airplane Flying Handbook, Chapter 4.

c. Step 1 – POWER IDLE
   - Power aggravates the spin characteristics, resulting in a flatter spin and increased rotation

d. Step 2 – AILERONS NEUTRAL
   - Ailerons may have an adverse effect on recovery
     - a Aileron in the direction of the spin may speed rotation, steepen spin attitude, & delay recovery
     - b Ailerons opposite the spin may cause flattening of the spin attitude and delayed recovery, or may even be responsible for causing an unrecoverable spin

e. Step 3 – RUDDER OPPOSITE THE ROTATION
   - Apply and hold FULL (to the stop) rudder opposite the direction of rotation until rotation stops
   - Rudder is the most important control for recovery in typical, single-engine airplanes, and its application should be brisk and full
     - a Avoid slow and overly cautious opposite rudder which can allow the airplane to spin indefinitely

f. Step 4 - ELEVATOR FORWARD
   - To break the stall, apply a positive/brisk, straight forward movement of the elevator
     - a Perform this step immediately after full rudder application – Don't wait for rotation to stop
     - b Hold the controls firmly in this position
     - c This will decrease the AOA and break the stall (spinning will stop when broken)
       1. Note: If airspeed is increasing, the airplane is no longer in a spin
       2. In the spin, the indicated airspeed is relatively low, constant/not accelerating

g. Step 5 – RUDDER NEUTRAL
   - Neutralize the rudder after the rotation stops
   - If not neutral the increased airspeed will cause a yawing or skidding effect
   - Also, if the stall is not broken and full rudder is held in the opposite direction a spin can quickly start in the direction of the rudder pressure

h. Step 6 – ELEVATOR BACK PRESSURE
   - Once broken, raise the nose to level flight - Be careful of a secondary stall and exceeding load limits
     - a Avoid aggressive movements resulting in an accelerated stall or a secondary stall
     - b Do not leave the aircraft in a nose low attitude while altitude decreases, and airspeed increases

7. Common Errors (AFH 5-21) AI.X.I.K13

A. Failure to apply full rudder pressure (to the stops) in the desired spin direction during spin entry
B. Failure to apply and maintain full up-elevator pressure during spin entry, resulting in a spiral
C. Failure to achieve a fully stalled condition prior to spin entry
D. Failure to apply full rudder (to the stops) briskly against the spin during recovery
E. Failure to apply sufficient forward-elevator during recovery
F. Waiting for rotation to stop before applying forward-elevator
G. Failure to neutralize the rudder after rotation stops, possibly resulting in a secondary spin
H. Slow and overly cautious control movements during recovery
I. Excessive back-elevator pressure after rotation stops, possibly resulting in secondary stall
J. Insufficient back-elevator pressure during recovery resulting in excessive airspeed

8. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. X. RM Concepts – Environmental Elements AI.X.K.R4
B. X. RM Concepts – Collision Hazards AI.X.K.R5

C. X. RM Concepts – Distractions, SA & Disorientation, & Task Management AI.X.K.R6

Conclusion:
Brief review of the main points
Spins can be dangerous, especially when close to the ground. Understanding the reasons a spin can happen and how to prevent one is extremely important. If coordination is maintained during a stall, a spin will not occur. Once in a spin, recovery is accomplished by PARE - power to idle, neutral ailerons, full opposite rudder along with forward elevator pressure to break the spin. The recovery should be performed with brisk, positive pressure.

X. RM Concepts

1. **Environmental Elements & Slow Flight**
   A. Turbulence
      i. Can increase the stall speed
         a. Sudden changes in the relative wind, and/or aggressive control inputs to maintain altitude can lead to exceeding the critical angle of attack and a stall
         b. In moderate to severe turbulence or strong crosswinds, use a higher-than-normal approach speed
      ii. Slow Flight: When flying below minimum drag speed (L/D_{MAX}) the aircraft exhibits speed instability
         a. If disturbed by turbulence and airspeed decreases, total drag increases, leading to further loss of speed
         b. Total drag continues to rise, and airspeed continues to fall
            - Without power and/or changes to pitch, speed will continue to decay down to the stall
            - Assuming aircraft stability doesn't prevent the problem
   B. Microbursts
      i. Strong downdraft normally occurring over 1 NM or less horizontally, and vertically less than 1,000'
         a. Can induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm
      ii. Depending on strength, climb ability can be minimized if not entirely eliminated
         a. Instinct can be to pitch excessively to counter the descent and avoid ground contact
            - Can quickly lead to a stall making the problem far worse than it already is
            - In the case of potential ground contact, increase pitch to minimize sink while avoiding a stall
      iii. In the case of a microburst follow the POH procedures, otherwise, general techniques include:
         a. FULL power and get the airplane climbing (best climb configuration & speed)
         b. If still descending, ensure max power, and increase pitch as far as possible without stalling
            - Intent is to keep the plane flying as long as possible in hope of exiting the shear
      iv. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common
      v. Aviation Weather Handbook (FAA-H-8083-28)
         a. See Ch. 22 pgs. 7-18 for details on recognizing/avoiding microbursts, and strategies for successful escape
   C. High Density Altitude
      i. Atmospheric Pressure
         a. Since air is a gas, it can be compressed or expanded, affecting density
         b. Changes in air density affect performance - As density increases, performance increases & vice versa
      ii. What Changes Air Density (DA)? Barometric Pressure, Temperature, Altitude, and Humidity
         a. Density varies directly with pressure - As pressure increases, density increases and vice versa
         b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
         c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
         d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa
      iii. How it affects Performance
         a. As the air becomes less dense, it reduces:
            - Power, since the engine takes in less air
            - Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)
            - Lift, because the thin air exerts less force on the airfoils
2. **Collision Hazards**
   A. Collision Avoidance
      i. Scanning
         a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
            - Each movement should not exceed 10°, each area should be observed for at least one second
         b. Divide attention between flying and scanning for aircraft

- Applicable in all phases of flight, especially important in high traffic areas

ii. Clearing Procedures
  a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
  b. Prior to any turn: Clear in the direction of the turn
  c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind

iii. Operation Lights On
  a. Voluntary FAA safety program to enhance the see and avoid concept
  b. Turn on landing lights during takeoff and when operating below 10,000', day or night
    - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected

iv. Right-of-Way Rules (FAR 91.113)
  a. An aircraft in distress has the right-of-way over all other traffic
  b. Converging Aircraft
    - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
    - If the aircraft are different categories:
      a Basically, the less maneuverable aircraft has the right-of-way
        1. Balloons, gliders, and airships have the right of way over airplanes
      b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
  c. Approaching Head-on: Each pilot shall alter course to the right
  d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
  e. Landing
    - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
      a Do not take advantage of this rule to force an aircraft off the runway which has already landed
    - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
      a Don't take advantage of this rule to cut in front of another aircraft

B. Terrain
  i. Plan well and be aware of terrain that could cause a hazard
    a. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
  ii. Day vs Night flying over terrain
    a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
    b. A personal minimum may be to only fly over high terrain during daylight
  iii. Minimum Safe Altitudes (FAR 91.119)
    a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
    b. Over Congested Areas: 1,000' above the highest obstacle within 2,000'
    c. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

C. Obstacles and Wire Strike
  i. Antenna Towers
    a. Numerous antennas extend over 1,000'-2,000' AGL
      - Most are supported by guy wires which are very difficult to see
      - Avoid all structures by at least 2,000' as guy wires can extend 1,500' horizontally from a structure
  ii. Overhead Wires (may not be lighted)
    a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
      - Lakes, highways, railroad tracks, etc.

3. Distractions, SA & Disorientation, & Task Management

A. Distractions
  i. They're dangerous
    a. Can lead to slow speeds, unintended aircraft attitudes, collisions, disorientation, missed radio calls, etc.

b. Remove distractions from your field of view or, in the case of a person, explain the situation and ask them to stop what they are doing
ii. Focus on aircraft performance
iii. Sterile flight deck
a. Maintain a sterile flight deck during taxi, takeoff, and climb as well as descent and landing
iv. Fly first! Aviate, Navigate, Communicate
a. Focus on the tasks at hand and stay ahead of the aircraft
b. Ensure checklists have been completed, and both you and the aircraft are prepared for what's next

B. Situational awareness (SA) & Disorientation
i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
ii. Maintain SA
a. Starts with preflight planning
b. Know what's coming next and stay ahead of the airplane
c. Be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
d. Divide attention between inside and outside references
e. If SA is lost, admit it
- If there's another pilot, let them take over while you catch up, if not, get the aircraft in a safe position and then solve the problem

iii. Disorientation can be caused by, or lead to, an upset
a. Push: Apply forward pressure to unload the plane
b. Roll: Roll aggressively to the nearest horizon
c. Thrust: Adjust as required
d. Stabilize: Return to a safe flight condition

C. Task Management
i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
a. No one responsibility should take your full attention full more than a short period
ii. Understand what tasks need to be accomplished and when
a. Prioritize based on importance and time available
b. Checklists and standard operating procedures are extremely helpful and enhance safety
iii. Recognize when you are getting behind and find a way to catch up
a. If more time is needed, find somewhere to hold/circle, or slow down
b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
c. "Attack the closest alligator" – Deal with the most pressing problem
iv. Proper task management can help prevent distractions, loss of SA, and disorientation
v. Safety is the number one priority – Aviate, Navigate, Communicate

BASIC INSTRUMENT MANEUVERS

XI.A-D. Basic Attitude Instrument Flight

References: Airplane Flying Handbook (FAA-H-8083-3), Instrument Flying Handbook (FAA-8083-15)

Objectives	The learner develops knowledge of basic attitude instrument flight and can smoothly and steadily control the aircraft, without the use of outside references. The learner will be able to perform this as required in the ACS.
Key Elements	1. Pitch + Power = Performance 2. Trim 3. Crosscheck 4. Adjust
Elements	1. Instrument Flying Hazards 2. Control & Performance 3. Establish 4. Trim 5. Crosscheck 6. Adjust 7. Straight-and-Level Flight 8. Turns to Headings 9. Constant Airspeed Climbs 10. Constant Airspeed Descents 11. Common Errors 12. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can smoothly and steadily control the airplane by reference to the instruments. They establish and maintain a thorough crosscheck and make the required adjustments to the flight attitude.

Instructor Notes:

Introduction:

Note: Basic instrument maneuver lessons A-D are often taught together, and therefore have been combined into a single lesson plan.

Attention

Interesting fact or attention-grabbing story

As you're flying you can see that the weather ahead looks like it might be getting worse. You think you can 'scud run' the rest of the way but, lo and behold, you unexpectedly enter a cloud and need to get out safely.

Overview

Review Objectives and Elements/Key ideas

What

Attitude instrument flying may be defined as the control of an aircraft's spatial position by using instruments rather than outside visual references.

Why

In the instance that you mistakenly fly into adverse weather, or don't have an outside horizon (night over water, haze, etc.) it is essential to be proficient flying the airplane without outside, visual references.

How:

1. RM: **Instrument Flying Hazards** AI.XI.A.R1
   A. Failure to Maintain VFR
      i. Risks include disorientation, loss of control, getting lost, icing, stress, midair/terrain, collision, and more
   B. Spatial Disorientation & Loss of Control
      i. Lack of orientation about the position, attitude, or movement of the airplane in space
      ii. In visual flight, the eyes prevail over any false sensations
      iii. In IMC, the eyes cannot correct for false sensations which can lead to disorientation
         a. For more details, see II.A. Human Factors
   C. Stress & Fatigue
      i. Inadvertent IMC is a stressful and mentally fatiguing exercise, especially to the non-proficient pilot
   D. Pilot Actions (Mitigation)
      i. Maintain proficiency in instrument flight
         a. Statistics show that a pilot who isn't trained in instrument flying, or has let their skills erode, loses control after about 10 minutes once forced to rely solely on instruments
         b. "We don't rise to the level of our expectations; we fall to the level of our training"
      ii. Thorough preflight planning and weather briefings
         a. Weather Reports and Charts
            - Begin looking at weather reports/expectations a few days prior flight
               a Build a more detailed picture as the flight gets closer & get a full briefing on the day of the flight
            - Do not go if the weather is not *at least* VMC along the entire route
               a Apply your own weather minimums based on experience, proficiency, comfort level, and safety
         b. Alternate Airports: Be familiar with alternates enroute in the case of deteriorating weather
            - Know where VMC should exist and divert prior to entering IMC
            - Mitigates considerable stress and risk associated with an emergency Landing

c. Terrain: Know minimum required altitudes for terrain avoidance

iii. Have a general plan

a. Turn on automation, use GPS moving map, contact ATC for assistance

b. Use preflight planning to know where VMC conditions should exist and planned divert airfields

iv. In the case unexpected weather results in less than VMC, use all options to safely exit:

a. Flight Instruments – Transition to instruments. Trust the instruments to avoid spatial disorientation

- Use the autopilot, if available, to decrease risk of spatial disorientation and reduce workload
- GPS – The moving map display & satellite weather are great tools for situational awareness

b. ATC – Inform ATC of the conditions and request assistance

- Other options may include Guard, FSS, other aircraft, cell phone, etc.

E. RM: Assistance & Emergencies AI.XI.A.R2

i. An emergency can either be a distress or urgency condition

a. Distress: Condition of being threatened by serious and/or imminent danger and of requiring immediate assistance

- Do not hesitate to declare an emergency when faced with distress conditions
- Ex: fire, mechanical failure, structural damage

b. Urgency: A condition of being concerned about safety and of requiring timely but not immediate assistance; a potential distress condition

ii. An aircraft is at least in an urgency condition the moment the pilot becomes doubtful about position, fuel endurance, weather, or any other condition that could adversely affect flight safety

a. This is the time to ask for help, not after it develops into a distress situation

iii. Request assistance immediately if apprehensive for your safety for any reason

a. Delay has caused accidents and cost lives

2. Control and Performance

A. Aircraft performance is achieved by controlling the aircraft attitude and power (AOA and thrust to drag) to produce the desired performance

i. In other words, Pitch + Power = Performance

B. The three general categories of instruments are control, performance, and navigation instruments

i. Control - Display immediate attitude and power indications and permit precise adjustments

a. Control is determined by reference to the attitude indicator and power indicators

b. Control covers the Pitch + Power portion of the equation

ii. Performance - Indicate the aircraft's actual performance

a. Performance is determined by reference to the Altimeter, airspeed indicator, VSI, heading indicator, and turn coordinator

iii. Navigation - Indicate the position in relation to a selected navigation facility or fix

a. Determined by course indicators, range indicators, glide-slope indicators and bearing pointers

C. Procedural Steps

i. *Establish* - an attitude/power setting on the control instruments resulting in the desired performance

a. Known or computed attitude changes and approximate power settings will help reduce workload

ii. *Trim* - until control pressures are neutralized.

a. Trimming is essential for smooth, precise control and allows attention to be diverted elsewhere

iii. *Crosscheck* - the performance instruments to determine if the desired performance is being obtained

a. Involves seeing and interpreting

b. If a deviation is noted, determine the magnitude and direction of correction necessary

iv. *Adjust* - the attitude or power setting on the control instruments as necessary

3. Establish AI.XI.A.K1b, AI.XI.A.K1c

A. The control instruments are used to set the necessary pitch and bank attitudes, and power setting

i. Aircraft attitude, or pitch, control is accomplished by properly using the attitude indicator

        a. Provides an immediate, direct, and corresponding indication of any change in pitch or bank
        b. Operation
            - Horizon disk is attached to double gimbal
                a Remains in the same plane as the gyro and the plane pitches/rolls about it
            - Adjustable mini aircraft appears to be flying relative to the horizon
        c. Limitations & Errors
            - Can spill if subjected to excessive pitch/bank attitudes (n/a to solid state/G1000 systems)
            - May be a slight nose-up indication during a rapid acceleration and vice versa
            - Possibility of a small bank angle and pitch error after a 180° turn
            - Tiny amounts of friction over time can cause precession/tilting
                a Erection mechanism (pull the knob) returns the gyro to the proper position
    ii. Aircraft power control is accomplished with the throttle
B. Pitch Control
    i. Changes are made by changing the pitch attitude by precise amounts in relation to the horizon
        a. Changes are measured in degrees or bar widths
        b. The amount of deviation from the desired performance will determine the magnitude of correction
C. Bank Control
    i. Changes are made by changing the bank attitude by precise amounts in relation to the bank scale
        a. Bank angle should normally approximate degrees to turn (10° turn=10° bank), not to exceed 30°
D. Power Control
    i. Made by throttle adjustments and reference to the power indicators
        a. Little attention is necessary to ensure the power setting remains constant
    ii. From experience, you know how far to move the throttles to change the power a given amount
        a. Make power changes primarily by throttle movement and then crosscheck the indicators
            - Don't fixate on the indicators while setting the power

4. RM: **Trim** AI.XI.A.R8

A. Trim the plane for hands off flight
    i. Set the desired pitch/power and trim the control pressures away
        a. Many small adjustments may be necessary
    ii. Momentarily let go of the stick to check the trim, if the aircraft does not maintain attitude, re-trim
    iii. Makes flying easier and opens mental capacity to fly the airplane/handle the problem
B. Do not fly the airplane with trim – set the pitch/power and trim the control pressures away

5. Crosscheck AI.XI.A.K1d

A. The continuous and logical observation of instruments for attitude and performance information
    i. The pilot maintains an attitude by reference to instruments that will give the desired performance
B. It is impossible to establish an attitude and have performance remain constant for a long period of time
    i. It is therefore necessary to constantly check the control and performance instruments and make appropriate changes to maintain the desired performance
C. Different Crosschecks
    i. Select Radial Crosscheck (2 pictures, right)

a. Most popular method – great for analog and digital displays
b. Based off the attitude indicator
   - Eyes never travel directly between the flight instruments, but move by way of the attitude indicator
c. Begin with the attitude indicator, scan an instrument and return to the attitude indicator before moving to another
d. Commonly referred to as the Hub and Spoke method
   - The attitude indicator is the hub and the primary reference for all maneuvers
   - Move from hub (attitude indicator) to spoke (performance instrument), back to hub, repeat

ii. Inverted V Crosscheck (analog displays – pictured below, left)
   a. Moving your eyes from the attitude indicator to the turn coordinator, up to the attitude indicator, to the VSI, and back to the attitude indicator

iii. Rectangular Crosscheck (analog displays – pictured below, right)
   a. Move your eyes across the top three instruments and drop down to scan the bottom three
   b. This gives equal weight to each instrument, regardless of its importance to the maneuver
   c. But this method lengthens the time for your eyes to return to a maneuver's critical instrument

D. Crosscheck and Bank

   i. After establishing, check the heading indicator and turn coordinator to ensure desired performance

E. Crosscheck and Pitch
   i. After establishing, check the Altimeter, VSI and airspeed indicator to ensure desired performance

F. Crosscheck Errors
   i. RM: Fixation AI.XI.A.R5
      a. Staring at a single instrument
      b. This occurs for a variety of reasons and eliminates the crosscheck of other pertinent instruments
      c. While fixated on the instrument, increasing tension may lead to unnoticed heading or pitch changes which leads to more errors
   ii. RM: Omission AI.XI.A.R5
      a. Omitting an instrument from the crosscheck
      b. May be caused by failure to anticipate major instrument indications following attitude changes
   iii. Emphasis (VSI - chasing is common or emphasizing pitch or bank instruments)
      a. Putting emphasis on a single instrument, instead of the necessary combination of instruments
      b. You may naturally tend to rely on the instrument most understood

G. RM: Instrument Interpretation AI.XI.A.R6
  i. Not only does the pilot have to be able to crosscheck the instruments in a logical and consistent manner, he or she must understand what they are indicating
  ii. Instrument interpretation is an understanding of each instrument's operation and the application of that knowledge to the performance of the aircraft
    a. Basically, the pilot must understand the information being received
  iii. For each maneuver, learn what performance to expect and the combination of instruments to be interpreted to control the aircraft

H. Instrument Operation & Limitations AI.XI.A.K1a, AI.XI.A.K1c
  i. Heading Indicator
    a. Gyro turns in a vertical plane, sensing rotation about the plane's vertical axis
    b. Compass is used to set the appropriate heading
      - Rigidity causes it to maintain this heading
    c. Precession causes heading to drift & Earth rotates 15^o per hour
      - Precession + rotation means heading should be checked/reset every 15 min
  ii. Turn Coordinator
    a. Canted gimbal allowing the gyro to sense both rate of roll as well as rate of turn
      - A rapid roll rate causes the mini aircraft to bank more steeply than a slow roll rate
    b. Used to establish and maintain a standard-rate turn (3^o per second)
      - Align the wing of the mini aircraft with the turn index
  iii. Airspeed Indicator
    a. Differential pressure gauge indicating the difference between pitot and static pressure
    b. Diaphragm receives pressure from pitot tube & instrument case receives pressure from static port
    c. Increasing pitot pressure/decreasing static pressure expands the diaphragm and vice versa
    d. Gearing indicates changes in airspeed
  iv. Altimeter
    a. Measures absolute pressure of the ambient air, displays it as feet above selected pressure level
      - Air pressure tries to compress aneroid wafers while natural springiness tries to expand them
        a Compression and expansion move gears/linkages to change the altitude displayed
      - Adjustable barometric scale (Kollsman window)
    b. Errors (Mechanical and Inherent)
      - Nonstandard Temperature
        a Warmer than standard air is less dense, pressure levels are farther apart
          1. True altitude > Indicated altitude
        b Colder than standard air is denser, pressure levels are closer together
          1. True altitude < Indicated altitude
      - Nonstandard Pressure
        a High pressure to Low pressure
          1. As pressure decreases, the altimeter registers it as a climb
          2. Pilot descends to maintain altitude
          3. True altitude < Indicated altitude
        b The opposite applies from Low pressure to High pressure – True alt > Indicated alt
      - From hot to cold, or from high to low, look out below!
  v. Vertical Speed Indicator
    a. Differential pressure instrument
    b. Diaphragm and casing are connected to static pressure
      - Diaphragm is directly connected while the case has a delayed connection

c. During a climb/descent, the diaphragm expands/contracts immediately, while pressure in the case remains the same for a short period
   - The difference in pressure is displayed as rate of climb

6. Adjust

A. Make the adjustments necessary in relation to the attitude indicator, then repeat the process again
   i. The amount of deviation from the desired performance will determine the magnitude of correction
      a. Restrict the attitude indicator's pitch displacement to 1 bar or ½ bar width up or down
      b. Use a bank angle that approximates the degrees to turn, not to exceed 30°
   ii. Smooth, small adjustments lead to smooth, steady control
   iii. Ensure a proper understanding of the instruments and their interpretation
   iv. Ensure an understanding of the aircraft performance capabilities, for example, the amount of pitch and power required to maintain straight-and-level, or a constant airspeed climb, etc.
   v. When a deviation is noted, correct using small, smooth adjustments

7. *Straight-and-Level Flight AI.XI.A.K1b

Pitch + Power = Desired Performance
Nose on Horizon + Cruise Power = Straight and Level

Control		Performance	
Pitch	On Horizon	Altimeter	Constant
Bank	Constant	VSI	0 fpm
Power	Cruise	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level / Coordinated

A. Establish - Use the attitude indicator to establish wings level, with nose on the horizon; adjust power as needed for cruise
B. Trim - Trim to relieve the control pressures
C. Crosscheck – Monitor the instruments for any performance deviations from straight-and-level flight
D. Adjust – Re-establish pitch (and power, if necessary) to correct for the deviations, trim the new control pressures, then crosscheck again. Continue to repeat

8. *Turns to Headings AI.XI.D.K1b

Pitch + Power = Desired Performance
Wings Banked/Nose Slightly High + Cruise Power = Turn to Heading

Control		Performance	
Pitch	Nose Slightly High	Altimeter	Constant
Bank	Wings Banked	VSI	0 fpm
Power	Cruise	Airspeed	Constant
		Heading	Turning
		Turn Coord	Banked/Coordinated

A. Prior to entering, determine which direction the turn should be made, and the angle of bank required
   i. Use an angle of bank equal to the number of degrees to turn, not to exceed 30°
B. Establish – Apply coordinated aileron and rudder to establish the bank angle on the attitude indicator
   i. If standard rate, use the turn coordinator
   ii. Adjust pitch as necessary (increase back pressure) to maintain level flight
C. Trim - Trim the airplane
D. Crosscheck – Monitor the instruments for any performance deviations from the turn
E. Adjust – Re-establish pitch (and power, if necessary) to correct for deviations, trim the new control pressures, crosscheck again. Repeat
F. Roll Out
   i. Apply coordinated rudder and aileron pressure to level the wings on the attitude indicator

a. Depending on the rate of turn, rollout 5-10º before the desired heading
   - Or use ½ the bank angle or less as a reference for small turns

ii. Adjust the pitch and power to maintain level flight at cruise airspeed

9. *Constant Airspeed Climbs AI.XI.B.K1b

Pitch + Power = Desired Performance
10º Nose Up + Full Power = Constant Airspeed Climb

Control		Performance	
Pitch	10º Nose Up	Altimeter	Climbing
Bank	Level	VSI	Positive Climb
Power	Climb Power	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level / Coordinated

A. Establish - Raise the nose of the aircraft to the approximate pitch attitude for the desired climb speed
   i. As the airspeed approaches the desired climb speed, set the power to the climb setting (full)

B. Trim -Trim to relieve the control pressures

C. Crosscheck – Monitor the instruments for any performance deviations from the climb

D. Adjust - Re-establish pitch (and power, if necessary) to correct for the deviations, trim the new control pressures, then crosscheck again. Continue to repeat
   i. Adjust the pitch attitude to maintain the desired climb airspeed (1 bar or ½ bar width movements)

E. Level Off
   i. Lead the altitude by 10% of the vertical speed (Ex: 500 fpm climb is led by 50')
   ii. Use the same procedure to level off the plane
      a. Establish - Reduce power and apply smooth steady elevator pressure toward a level attitude on the attitude indicator
      b. Crosscheck - VSI, Altimeter and attitude indicator should show level flight
      c. Trim the airplane and maintain straight and level flight
      d. Continue to repeat the process in the new attitude

F. Turning Climbs
   i. In the case of the turn, apply the same procedures as above, and establish the desired bank angle in the desired direction on the attitude indicator
      a. Monitor the performance of the turn on the heading indicator and turn coordinator
      b. Small adjustments to pitch and power may be necessary to maintain airspeed with the bank
      c. The instrument crosscheck will have to be accelerated as there is more information to take in
         - Crosscheck the climb, airspeed, and heading change, and plan ahead for the level-off and the roll-out from the turn (they may not happen simultaneously)

10. *Constant Airspeed Descents AI.XI.C.K1b

Pitch + Power = Desired Performance
3º Nose Down + Descent Power = Constant Airspeed Descent

Control		Performance	
Pitch	3º Nose Down	Altimeter	Descending
Bank	Level	VSI	Negative Climb
Power	Descent Power	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level / Coordinated

A. Establish - Reduce power to a predetermined setting for the descent and maintain straight and level flight as airspeed decreases
   i. As the airspeed approaches the desired level, lower the nose with the attitude indicator to maintain a constant speed

B. Trim - Trim to relieve the control pressures
C. Crosscheck – Monitor the instruments for any performance deviations from the desired descent
D. Adjust – Re-establish pitch (and power, if necessary) to correct for the deviations, trim the new control pressures, then crosscheck again. Continue to repeat
    i. Adjust the pitch attitude to maintain the desired climb airspeed
E. Level Off
    i. Lead the altitude by 10% of the vertical speed (Ex: 500 fpm descent is led by 50')
    ii. Use the same procedure to level off the plane
        a. Establish - Introduce power and apply smooth steady elevator pressure toward a level attitude
        b. Crosscheck - VSI, Altimeter and attitude indicator should show level flight
        c. Trim the airplane and maintain straight and level flight
        d. Continue to repeat the process in the new attitude
F. Turning Descents
    i. In the case of the turn, apply the same procedures as above, and establish the desired bank angle in the desired direction on the attitude indicator
        a. Monitor the performance of the turn on the heading indicator and turn coordinator
        b. Small adjustments to pitch and power may be necessary to maintain airspeed with the additional bank
        c. The instrument crosscheck will have to be accelerated as there is more information to take in
            - Monitor the descent, airspeed, and heading change, and plan ahead for the level-off and the roll-out from the turn (they may not happen simultaneously)

11. Common Errors AI.XI.A.K2

A. "Fixation," "Omission," and "Emphasis" errors during instrument cross-check
B. Improper instrument interpretation
C. Improper control applications
D. Failure to establish proper pitch, bank, or power adjustments during altitude, heading, or airspeed corrections
E. Improper entry or level-off procedure (specific to Constant Airspeed Climbs and Descents)
F. Improper entry or roll-out procedure (specific to Turns to Headings)
G. Faulty trim procedure

12. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. XI. RM Concepts – Collision Hazards AI.XI.A.R3
B. XI. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.XI.A.R4

RM: Control application solely by reference to instruments AI.XI.A.R7

The lesson as a whole is a discussion on the risk management of flying solely by reference to instruments

Conclusion:

Brief review of the main points

In visual flight, you control aircraft attitude in relation to the natural horizon by using certain reference points on the aircraft. In instrument flight, you control aircraft attitude by reference to the flight instruments. A proper interpretation of the flight instruments will give you essentially the same information that outside references provide in visual flight.

Private Pilot ACS Skills Standards

Straight-and-Level Flight

1. Maintain altitude ±200', heading ±20°, and airspeed ±10 knots.

Constant Airspeed Climbs

1. Level off at the assigned altitude and maintain altitude ±200', heading ±20° and airspeed ±10 knots.

Constant Airspeed Descents

1. Level off at the assigned altitude and maintain altitude ±200’, heading ±20° and airspeed ±10 knots.

Turns to Headings

1. Demonstrate turns to headings, maintain altitude ±200’ and maintain a standard rate turn and rolls out on the assigned heading ±10°; maintain airspeed ±10 knots.

XI.E. Recovery from Unusual Flight Attitudes

References: Airplane Flying Handbook (FAA-H-8083-3), Instrument Flying Handbook (FAA-8083-15)

Objectives	The learner develops knowledge of unusual flight attitude recoveries as required in the ACS.
Key Elements	1. Crosscheck 2. Recovery 3. Coordination
Elements	1. General 2. Unusual Attitude Situations and Conditions 3. Preventing Unusual Attitudes 4. Recognizing Unusual Attitudes 5. Recovery Basics 6. Nose High (Climbing Turn) Recovery 7. Nose Low (Diving Spiral) Recovery 8. Coordination During Recovery 9. Common Errors 10. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands how unusual flight attitudes can occur, and the proper recovery procedure for a nose low or nose high unusual flight attitude. They can perform the recoveries in the airplane to ACS standards.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

On July 16, 1999, JFK Jr. was killed along with his wife and sister-in-law, when the aircraft he was piloting crashed into the Atlantic Ocean. Kennedy had 310 hours of flight experience, including 55 hours of night flying and 36 hours in the high-performance Piper Saratoga. He had completed about half of an instrument training course. The NTSB investigation found no evidence of mechanical malfunction and determined that the probable cause was the pilot's failure to maintain control of the airplane during a descent over water at night, which was a result of spatial disorientation (or, not recovering properly from an unusual attitude). Factors in the accident were haze, and the dark night.

Overview

Review Objectives and Elements/Key ideas

What

An unusual attitude is an airplane attitude not normally required for flight.

Why

Without proper recovery training in instrument interpretation and aircraft control, a pilot can quickly aggravate an abnormal flight attitude into a potentially fatal accident.

How:

1. **General**
   - A. Since unusual attitudes (UAs) are not intentional maneuvers, they are often unexpected
     - i. The reaction is, therefore, instinctive rather than intelligent and deliberate
       - a. Individuals usually react with abrupt muscular effort, which is purposeless and even hazardous in turbulent conditions, at excessive speeds, or at low altitudes
   - B. When an unusual attitude is noticed, the immediate problem is not how it got there, but what is the aircraft doing and how to get it back to straight and level flight as quickly as possible
2. **RM: Unusual Attitude Situations and Conditions** AI.XI.E.R1
   - A. Unusual attitudes may result from various situations/conditions, such as:
     - Turbulence
     - Disorientation
     - Instrument Failure
     - Stress or Confusion
     - Preoccupation with flight deck duties
     - Task saturation
     - Errors in instrument interpretation/crosscheck
     - RM: Control input errors leading to a UA
3. **Preventing Unusual Attitudes** (Top Causal Factors) AI.XI.E.K1
   - A. Environmental Factors
     - i. Turbulence or large variations in wind velocity over a short distance
       - a. Clear air turbulence, mountain waves, wind shear, thunderstorms, microbursts
     - ii. Maintain awareness of conditions that can lead to environmental factors
   - B. Mechanical Factors
     - i. Mechanical Failures
       - a. May cause a departure from normal flight
       - b. Asymmetrical flaps, malfunctioning or binding flight controls, runaway trim
     - ii. Instrument Failures

a. Learn to recognize and be alert to instrument failure indications
b. Be proficient in the use of secondary instrumentation and partial panel operations

iii. Improper Trim Technique
   a. Failure to keep the plane trimmed can turn a momentary distraction into an unusual attitude
iv. Autopilot Malfunctions AI.XI.E.K4
   a. Malfunctions or misuse of the autopilot can lead to a loss of situational awareness
   b. Can be insidious – the pilot may not be aware there's a problem until deep in a UA
   c. Disengage the autopilot and fly the airplane
      - Maintain manual flight proficiency in all conditions without an automation
v. Big picture: Knowledge of systems and POH procedures helps minimize failures and prevent UAs

C. Human Factors
   i. VMC to IMC
      a. A loss of the natural horizon significantly increases the chances of spatial disorientation & vertigo
      b. Be aware of weather reports & conditions and where IMC may exist
      c. Be proficient in flying with the instruments and have a plan to return to VMC
   ii. Diversion of Attention
      a. Diverting attention from flying to an anomaly, malfunction, or any other distraction can lead to a UA
      b. Fly first
         - Maintain situational awareness, monitor automated systems, etc.
   iii. Task Saturation
      a. Poor SRM/CRM skills
         - Major cause of CRM accidents is a failure to maintain an organized flight deck
         - A disorganized flight deck can lead to distraction that interrupts the crosscheck long enough for a UA
      b. The margin of safety is the difference between task requirements & pilot capabilities
         - UAs can occur when requirements exceed capabilities
   iv. Fixation
      a. Too much attention is focused on one instrument – keep the crosscheck moving
   v. Sensory Overload/Deprivation
      a. A pilot's ability to correlate and manage warnings, annunciations, instrument indications is limited
         - Especially during a UA that can present multiple visual, auditory, and tactile warnings
      b. An effective crosscheck is very important to determine the issue and maintain control
         - Separating time-critical info from distractions takes practice, experience, & aircraft expertise
         - Also important to be able to determine if information is missing or invalid
            a For example, stall warning failure (recognize buffet, mushy controls, descent rate, etc.)
   vi. Spatial Disorientation (SD)
      a. Significant factor in many upset accidents
         - More than 200 accidents from 2008-2013, more than 70% were fatal
      b. Everyone is susceptible to illusions, especially at night or in IMC
      c. Pilots experience SD or perceive the situation in one of the following ways:
         - Recognized SD: Pilot recognizes the situation & safely corrects
         - Unrecognized SD: Unaware of the UA and fails to take corrective action
         - Incapacitating SD: Unable to recover due to some combination of:
            a Not understanding the events
            b Lacking the skills required
            c Exceeds psychological or physiological ability to cope with the situation
      d. Understanding, training & practice are necessary to maintain situation awareness and recover safely
   vii. Surprise & Startle Response

a. Surprise: Unexpected event that violates expectations & affects the mental process used to respond
b. Startle: Uncontrollable, automatic muscle reflexes, raised heart rate, blood pressure, etc., elicited by exposure to a sudden, intense event that violates a pilot's expectations
c. Untrained pilots often experience a state of surprise & startle response to UAs
   - Training, especially scenario-based training, can protect against these reactions/responses
d. "We don't rise to the level of our expectations; we fall to the level of our training"
   - Without effective UA training, you won't naturally know how to react
   - In surprise/startle (fight or flight) situations you will react within the limits of your training

viii. Flight by sensory sensations other than sight
   a. Flight by instinct, without visual references, almost always leads to erroneous corrections

ix. Failure to practice Basic Attitude Instrument (BAI) flight
   a. If you don't use it, you lose it – BAI skills diminish if they're not practiced
   b. See lesson II.A. Human Factors for more details on illusions, spatial disorientation, etc.

4. RM: **Recognizing Unusual Attitudes** (Assessment of Unusual Attitudes) AI.XI.E.R2

A. General Rule: If you note an instrument rate of movement or indication other than those you associate with the basic instrument flight maneuvers, assume an unusual attitude, and increase the speed of crosscheck to confirm the attitude, or instrument error, or instrument malfunction
B. When an unusual attitude is noticed on your crosscheck, the immediate problem is not how it got there, but what is the aircraft doing and how to get it back to straight and level flight as quickly as possible
C. Unusual attitudes are broken down into two categories: Nose high, and Nose low attitudes
D. Nose High Attitudes (Climbing Turn)
   i. Shown by the rate/direction of movement of the altimeter, VSI, and airspeed indicator as well as the immediately recognizable indication of the attitude indicator (except in extreme attitudes)
      a. Decreasing airspeed
      b. Increasing altitude
      c. Positive rate of climb
      d. The turn coordinator indicates a bank
      e. A lot of blue on the attitude indicator
E. Nose Low Attitudes (Diving Spiral)
   i. Shown by the same instruments but in the opposite directions
      a. Increasing airspeed
      b. Decreasing altitude
      c. Negative rate of climb
      d. The turn coordinator indicates a bank
      e. A lot of brown on the attitude indicator

5. RM: **Recovery Basics** (Interpreting Flight Instruments) AI.XI.E.K2, AI.XI.E.R6

A. In moderate UAs, the pilot can normally reorient with the attitude indicator, but this should not be done:
   i. If the attitude indicator is spillable - its upset limits may have been exceeded and is unreliable
   ii. It may have become inoperative due to mechanical malfunction, and is a reason for the UA
   iii. Even if it isn't spillable and is operating properly, errors of up to 5º pitch and bank may result
   iv. Indications are difficult to interpret in extreme attitudes
B. Recovery, instead, is initiated by reference to the airspeed indicator, altimeter, VSI, and turn coordinator
   i. Follow the POH recommended recovery procedures if they differ from the information here
C. RM: Nose High vs Nose Low Unusual Attitudes (Operating Envelope Considerations) AI.XI.E.R8
   i. Although similar, the recovery procedures for each are different
   ii. The basic intent of the nose high recovery is to prevent a stall
   iii. The basic intent of the nose low recovery is to prevent over stressing the airplane

6. Nose High (Climbing Turn) Recovery AI.XI.E.K2

A. Nose High Attitudes (Main Point: Avoid a stall) - If the airspeed is decreasing, or below that desired:

B. Procedure
   i. Power: Increase power as necessary (in proportion to the deceleration)
   ii. Pitch: Apply forward elevator pressure to lower the nose (reduces AOA to prevent a stall)
   iii. Bank: Correct bank with coordinated aileron/rudder pressure by reference to the turn coordinator
   iv. The steps listed are made in the sequence described above, but occur almost simultaneously
C. After initial control has been applied, continue with a fast cross-check for possible overcontrolling
   i. As the rate and movement of the altimeter and airspeed indicator needles decrease, the attitude is approaching level flight
   ii. When the needles stop and reverse direction, the aircraft is passing through level flight
D. Return to the desired altitude, and establish/verify straight-and-level, coordinated cruise flight
   i. Level Flight is indicated by:
      a. Reversal and stabilization of the altimeter and airspeed indicator
   ii. Straight and Coordinated Flight is indicated by:
      a. Level miniature aircraft and centered ball on the turn coordinator
   iii. Set power to maintain the desired airspeed once the airspeed is under control

7. Nose Low (Diving Spiral) Recovery AI.XI.E.K2

A. Nose Low Attitudes (Main Point: Avoid over G-ing) - If the airspeed is increasing, or above that desired:
B. Procedure
   i. Power
      a. Reduce power to prevent excessive airspeed and loss of altitude
   ii. Bank

    a. Level the wings
    b. Correct bank with coordinated aileron/rudder pressure by reference to the turn coordinator
    c. Leveling the wings prior to raising the nose reduces the load factors in the recovery
  iii. Pitch
    a. Raise the nose to level flight attitude by applying smooth back-elevator pressure
      - Smooth back pressure avoids overstressing the airplane
      - If ground contact is a concern, use whatever back pressure necessary to survive
  iv. All components of control should be changed simultaneously for a smooth, proficient recovery
C. After initial control has been applied, continue with a fast cross-check for possible overcontrolling
  i. As altimeter and airspeed indicator movement decreases, the attitude is approaching level flight
  ii. When the needles stop and reverse direction, the aircraft is passing through level flight
D. Return to the desired altitude, and establish/verify straight-and-level, coordinated cruise flight
  i. Level Flight is indicated by:
    a. Reversal and stabilization of the altimeter and airspeed indicator
  ii. Straight and Coordinated Flight is indicated by:
    a. Level miniature aircraft and centered ball on the turn coordinator
  iii. Set power to maintain the desired airspeed once the airspeed is under control
  iv. With an operative attitude indicator, level flight exists when the miniature plane is level with the horizon
  v. Without the attitude indicator, level flight is indicated by the reversal and stabilization of the airspeed indicator and altimeter

8. Coordination During Recovery
A. The attitude indicator and turn coordinator should be checked to determine and maintain straight/coordinated flight (wings level, ball centered)
  i. Skidding and slipping sensations can easily aggravate disorientation and retard recovery
  ii. A nose low recovery could result in excessive Gs *and* uncoordinated flight, causing big problems

9. Common Errors AI.XI.E.K5
A. RM: Inappropriate control applications during recovery (can aggravate or further induce a UA) AI.XI.E.R3
B. Failure to recognize an unusual flight attitude
C. Consequences of attempting to recover from a UA by "feel" rather than by instrument indications
D. Inappropriate control applications during recovery
E. Failure to recognize from instrument indications when the airplane is passing through a level flight attitude

10. Hazards
A. Inadvertent Flight into IMC AI.XI.E.K3
  i. Importance of Instrument Flight
    a. Statistics show that a pilot who isn't trained in instrument flying, or has let their skills erode, loses control after about 10 minutes once forced to rely solely on instruments
  ii. Recognize
    a. Anytime a pilot is unable to maintain control by reference to the natural horizon, the condition is IMC
      - Regardless of circumstances or weather conditions
    b. Recognize the situation and accept it as a genuine emergency requiring action
  iii. RM: Maintain Control (Control Application Solely by Reference to Instruments) AI.XI.E.R7
    a. The *only* way to control the airplane safely is by using and trusting the flight instruments
      - Attempts to partially control the plane by instruments can lead to disorientation and loss of control
    b. The most important concern at this point is to keep the wings level
      - Do not panic
      - An uncontrolled turn usually leads to difficulties with overall control and can lead to disorientation
    c. Believe the flight instruments regardless of your senses

  - False sensations are common, and will lead to disorientation
- d. Attitude Control
  - Trim for hands-off level flight at cruise speed
  - Don't over-control
    - a Fly the attitude indicator with fingertip control
    - b Don't make changes unless the instruments indicate a definite need for change
  - Make smooth and small attitude changes
    - a The attitude indicator is the primary instrument for attitude control
      1. No more than one bar width movements up or down
  - Use any aids (autopilot, wing leveler, etc.)
    - a Automation can be a huge assistance to the pilot AI.XI.E.K4
      1. Used properly, it can greatly increase SA & orientation, freeing the pilot to focus on more pressing tasks
  - Maintain cruise speed (turns, climbs, descents) until required to slow for landing
  - See XI.A-D. Basic Attitude Instrument Flight

iv. Obtain Assistance
- a. ATC/Flight Following: If able, inform ATC and ask for vectors to VMC
- b. Guard (121.5), or other available frequencies: Request help
  - Guard can likely provide a frequency for a nearby controller
- c. Weather charts: Be aware of expected VMC conditions

v. Find/Return to VMC
- a. The best option may be to bug your heading, engage the autopilot (if available) and perform a 180° turn
  - Return to the last known VMC (terrain, airspace, etc. permitting)

vi. Request assistance & weigh all options

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

B. XI. RM Concepts – Collision Hazards AI.XI.E.R4
C. XI. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.XI.E.R5

Conclusion:
Brief review of the main points
When recovering from an unusual attitude, it is essential to ignore the attitude indicator and use the airspeed indicator, altimeter, turn coordinator, heading indicator and VSI to determine the attitude of the aircraft. Recovery should be made promptly in the proper order to avoid damaging the airplane or inducing a stall. Once level flight has been attained, the airplane should be reconfigured for straight-and-level flight.

XI. RM Concepts

1. **Collision Hazards**
   A. Collision Avoidance
      i. In the case of IMC
         a. Request assistance - If in radar contact, ATC can assist with traffic and terrain avoidance
      ii. Scanning
         a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
            - Each movement should not exceed 10º, each area should be observed for at least one second
         b. Divide attention between flying and scanning for aircraft
            - Applicable in all phases of flight, especially important in high traffic areas
      iii. Clearing Procedures
         a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
         b. Prior to any turn: Clear in the direction of the turn
         c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind
      iv. Operation Lights On
         a. Voluntary FAA safety program to enhance the see and avoid concept
         b. Turn on landing lights during takeoff and when operating below 10,000', day or night
            - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected
      v. Right-of-Way Rules (FAR 91.113)
         a. An aircraft in distress has the right-of-way over all other traffic
         b. Converging Aircraft
            - When aircraft of the same category are converging, the aircraft to the right has the right-of-way
            - If the aircraft are different categories:
               a Basically, the less maneuverable aircraft has the right-of-way
                  1. Balloons, gliders, and airships have the right of way over airplanes
               b An aircraft towing or refueling an aircraft has the right-of-way over all engine driven aircraft
         c. Approaching Head-on: Each pilot shall alter course to the right
         d. Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
         e. Landing
            - Aircraft landing/on final approach to land have the right-of-way over those in flight or on the surface
               a Do not take advantage of this rule to force an aircraft off the runway which has already landed
            - When two or more aircraft are approaching for landing, the lower aircraft has the right-of-way
               a Don't take advantage of this rule to cut in front of another aircraft
   B. Terrain
      i. Plan well and be aware of terrain that could cause a hazard
         a. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
      ii. Day vs Night flying over terrain
         a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
         b. A personal minimum may be to only fly over high terrain during daylight
      iii. Minimum Safe Altitudes (FAR 91.119)
         a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
         b. Over Congested Areas: 1,000' above the highest obstacle within 2,000'
         c. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure
   C. Obstacles and Wire Strike
      i. Antenna Towers

a. Numerous antennas extend over 1,000’-2,000’ AGL
   - Most are supported by guy wires which are very difficult to see
   - Avoid all structures by at least 2,000’ as guy wires can extend 1,500’ horizontally from a structure

ii. Overhead Wires (may not be lighted)
   a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
      - Lakes, highways, railroad tracks, etc.

2. Distractions, SA & Disorientation, & Task Management

A. Distractions
   i. They’re dangerous
      a. Can lead to slow speeds, unintended aircraft attitudes, collisions, disorientation, missed radio calls, etc.
      b. Remove distractions from your field of view or, in the case of a person, explain the situation and ask them to stop what they are doing
   ii. Sterile flight deck
      a. Implement and maintain a sterile flight deck during taxi, takeoff, and climb as well as descent and landing
   iii. Fly first! Aviate, Navigate, Communicate - Focus on the tasks at hand and stay ahead of the aircraft
      a. Especially important to avoid distractions in an emergency with numerous tasks to manage
      b. Ensure checklists have been completed, and both you and the aircraft are prepared for what’s next

B. Situational awareness (SA) & Disorientation
   i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
   ii. Maintain SA
      a. Starts with preflight planning
      b. Know what’s coming next and stay ahead of the airplane
      c. Be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
      d. Divide attention between inside and outside references
      e. If SA is lost, admit it
         - If there’s another pilot, let them take over while you catch up, if not, get the aircraft in a safe position (if landing, go around; if disoriented, trust the instruments and get to a safe attitude/altitude) and then solve the problem
   iii. Disorientation can be caused by, or lead to, a UA
      a. Recognize & apply proper recovery procedures
   iv. Lack of Visual References
      a. Can be very disorienting: Trust the instruments, use automation, ask for help, return to VMC
      b. For more details, see II.B. Visual Scanning & Collision Avoidance and II.M. Night Operations

C. Task Management
   i. Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
      a. No one responsibility should take your full attention full more than a short period
   ii. Practice SRM/CRM skills & maintain an organized flight deck
   iii. Understand what tasks need to be accomplished and when
      a. Prioritize based on importance and time available
      b. Checklists and standard operating procedures are extremely helpful and enhance safety
   iv. Recognize when you are getting behind and find a way to catch up
      a. If more time is needed, find somewhere to hold/circle, or slow down
      b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
      c. “Attack the closest alligator” – Deal with the most pressing problem
   v. Proper task management can help prevent distractions, loss of SA, and disorientation
   vi. Safety is the number one priority – Aviate, Navigate, Communicate

EMERGENCY OPERATIONS

XII.A. Emergency Descent

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of when an emergency descent is required, and the proper procedure to perform the maneuver. The learner can perform the maneuver as required in the ACS.
Key Elements	1. Configuration 2. Airspeed and Load 3. Recovery
Elements	1. Basics 2. Emergency Descent Procedures 3. Descent Factors 4. Common Errors 5. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands the situations which necessitate an emergency descent and can properly perform the maneuver with a smooth, controlled recovery.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

This maneuver is a lot of fun to practice, partly because there is not a lot too it, but also because the airplane is put in a very nose low attitude and is descending very fast. You're dive bombing the ground.

Overview

Review Objectives and Elements/Key ideas

What

An emergency descent is a maneuver for descending as rapidly as possible to a lower altitude, or to the ground for an emergency landing.

Why

The need for this maneuver may result from an uncontrollable fire, a sudden loss of cabin pressurization, or any other situation demanding an immediate and rapid descent for survival.

How:

1. **Basics** AI.XII.A.K1, AI.XII.A.K2
   - A. Objective
     - i. To descend as soon and as rapidly as possible, within the structural limitations of the airplane
   - B. Situations
     - i. Fire, smoke, loss of cabin pressurization, or any other demanding situation (medical, injury, etc.)
     - ii. Failing to identify the necessity for an emergency descent can be fatal
       - a. A fire can grow/spread quickly – often considered the most threatening hazard in an airplane
       - b. In the case of decompression, symptoms of hypoxia can set in
   - C. POH AI.XII.A.K3, AI.XII.A.K4, AI.XII.A.K5
     - i. Follow the procedures outlined in the Emergency Procedures section of the POH
       - a. Reference immediate action/memory items (essential to quick action in a serious emergency)
       - b. Reference any associated performance charts
     - ii. Reference & note any applicable aircraft limitations
       - a. V_{NE}, flap/gear speed restrictions, structural requirements, etc.
2. **Emergency Descent Procedures** AI.XII.A.K1
   - A. Prior to the Maneuver
     - i. Clear the area visually
       - a. Thoroughly clear the area and broadcast intentions to alert other aircraft
       - b. Ensure it is clear below the aircraft – turns are likely necessary, especially in low wing aircraft
     - ii. *Pre-Maneuver Checklist: Fuel Pump ON, Mixture RICH, Lights ON, Gauges GREEN
   - B. Procedure
     - i. Accomplish immediate action items per the POH
     - ii. Reduce power to idle
     - iii. RM: Configuring the Airplane AI.XII.A.R3
       - a. Follow the POH Procedures - Extend the flaps and gear as required by the manufacturer
         - Provides maximum drag to make increase the rate of descent, without excessive airspeed
       - b. Improper configuration can result in less than desired rate of descent, and/or structural damage

- Ex. Leaving the flaps up could decrease the rate of descent and increase airspeed, potentially exceeding limitations (V_{NE}), and overstressing the airplane during recovery

iv. Put the nose down to maintain the maximum allowable airspeed based on the procedure
  a. *Nose down pitch is approximately 12°, but may be adjusted based on the configuration
  b. This speed may vary based on flaps used, the nature of the emergency, and turbulent conditions
    - Never exceed V_{NE} or V_{FE} and always maintain positive control of the airplane
    - In an engine fire, a high-speed descent could blow out the fire, however, weakening of the structure is a concern, and a low airspeed would result in less airframe stress
    - In the case of turbulence, do not exceed V_A

v. As the nose is lowered, establish a 30-45° bank
  a. Puts positive load on the aircraft (countering the negative load from the descent)
  b. Assists with clearing (below and to each side) and gets the airplane off an airway
  c. Technique: Use a left turn as faster traffic passes on the right (right-of-way rules)
    - Balance this with other factors – terrain, airspace, other airways, etc.

vi. Maintain the required airspeed until close to the desired altitude

C. Leveling Off (often the most difficult part)
  i. The recovery should be smooth to prevent overstressing the airplane
    a. These recommendations generally work well, but in the case of a real-life emergency descent (i.e. a fire in the cabin), do what is necessary to land safely/stay alive
    b. Initiate the level off at an altitude that will ensure a safe recovery or precautionary landing
    c. The 10% rule works well
      - Ex: If descending at 1500 fpm, start the level off 150' above the desired altitude
  ii. Increase power to the cruise setting, or as required
  iii. Once straight and level, return the airplane to a normal configuration (flaps, gear, etc. are retracted)
  iv. Re-trim the aircraft and adjust/lean the mixture as necessary

3. RM: **Descent Factors** AI.XII.A.R1

A. Altitude
  i. Dictates the amount of descent
    a. Recommended to be at/below 10,000' in the case of depressurization (terrain/safety permitting)
  ii. In the case of an engine failure, altitude will dictate the distance the aircraft can travel
    a. Use AGL, not MSL. Depending on where the aircraft is flying these altitudes can be very different

B. Wind
  i. During the descent
    a. Take wind into account during the descent and approach to landing
      - Can have a large effect on glide distance in the case of an engine failure
      - Headwind vs tailwind vs crosswind
  ii. Landing
    a. Maximum Demonstrated Crosswind Component
      - Use the manufacturer's flight manual to find the maximum allowable crosswind component
      - Don't exceed it, the aircraft may not be able to remain within the confines of the runway
    b. Tailwind
      - A tailwind increases the runway required for landing
        a Don't exceed the POH tailwind limitation (exception: emergency)
    c. Always verify the wind conditions and landing performance are compatible with the runway

C. Terrain & Obstructions
  i. Be familiar with and especially cautious of terrain & obstructions during an emergency descent
    a. It's easy to get distracted during high speed, high rate of descents in conjunction with an emergency

        b. Start the level off to preclude descending through the desired altitude and potentially impacting terrain/obstructions
    D. Glide Distance
        i. In the case the engine fails, and the aircraft has to glide to the landing area, terminate the emergency descent at a time appropriate to the situation and transition to best glide speed
            a. Be established at the best glide speed at a point at which to make a safe and controlled landing
            b. Know the approximate distance the aircraft can travel based on the altitude available
                - Adjust the descent as necessary to land at the desired landing area

4. Common Errors AI.XII.A.K6
    A. The consequences of failing to identify reason for executing an emergency descent
    B. Improper use of the prescribed emergency checklist to verify accomplishment of procedures for initiating the emergency descent
    C. Improper use of clearing procedures for initiating the emergency descent
    D. Improper procedures for recovering from an emergency descent

5. RM: Hazards

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.
    A. XII. RM Concepts – Collision Hazards AI.XII.A.R2
    B. XII. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.XII.A.R4

Common Errors: AI.XII.A.K6
- The consequences of failing to identify reason for executing an emergency descent
- Improper use of the prescribed emergency checklist to verify accomplishment of procedures for initiating the emergency descent
- Improper use of clearing procedures for initiating the emergency descent
- Improper procedures for recovering from an emergency descent

Conclusion:
Brief review of the main points
An emergency descent is used in a situation where altitude must be lost quickly to make a landing as soon as possible. If possible, the manufacturer’s procedures should be followed. The airplane is put into a configuration which will allow for the maximum descent rate. Recovery should be smooth and controlled as straight and level cruise flight is reestablished.

Private Pilot ACS Skills Standards
1. Use a bank angle between 30° and 45° to maintain positive load factors during the descent.

Commercial Pilot ACS Skills Standards
1. Use a bank angle between 30° and 45° to maintain positive load factors during the descent.
2. Maintain appropriate airspeed +0/-10 knots, and level off at specified altitude, ± 100 feet.

XII.B. Emergency Approach & Landing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of the elements related to performing an emergency approach and landing. The learner will be able to perform the maneuver as required in the ACS.
Key Elements	1. Best Glide Airspeed 2. Emergency Checklists 3. Soft Field Power Off Approach and Landing
Elements	1. Best Glide Speed 2. ABC Checklist 3. Emergency Approach 4. Contacting ATC 5. Emergency Landing 6. Descent Factors 7. Emergency Locating Devices 8. Mental Attitude 9. Common Errors 10. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can simulate an emergency approach and landing, taking into account the landing area, and wind while accomplishing the necessary checklists and properly positioning the airplane to land safely on the desired landing spot.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Understanding the elements behind a properly executed emergency approach and landing could be the difference between a safe soft field landing and a dangerous, poorly performed crash.

Overview

Review Objectives and Elements/Key ideas

What

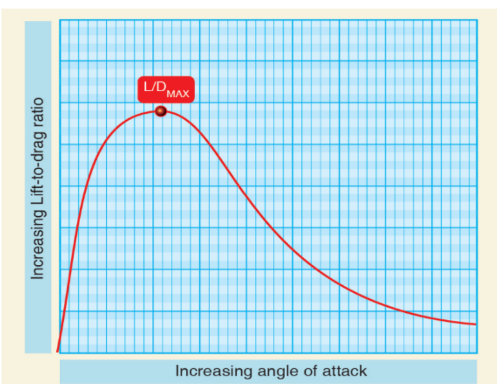
A simulated emergency landing occurs when the power is pulled, simulating a lost engine, and the pilot must run the checklist to attempt to restart the engine while properly configuring the airplane for an approach and landing usually in a nearby field.

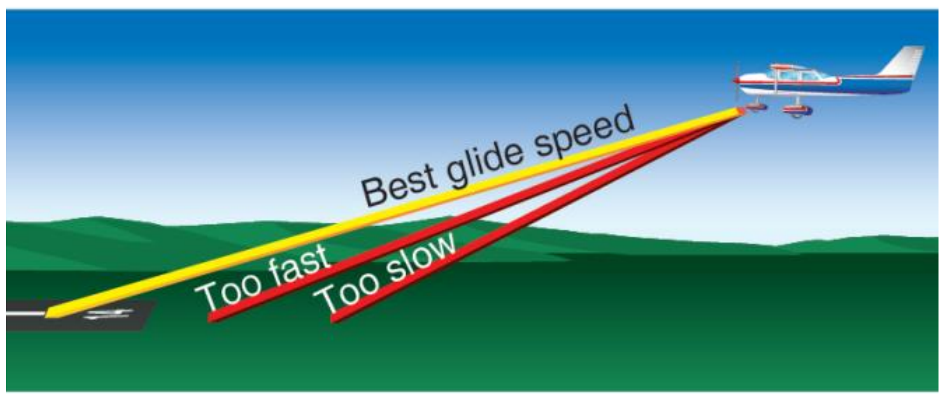
Why

To develop accuracy, judgment, planning, technique, and confidence when little or no power is available.

How:

1. **Best Glide Speed** AI.XII.B.K2
   A. Airspeed at which the aircraft glides the furthest for the least altitude lost in non-powered flight AI.XII.B.K2a
      i. Used to maximize the distance flown without power
      ii. Occurs at the highest lift-to-drag ratio (L/D)
         a. Above or below this speed, drag increases and distance flown decreases





   B. Glide Ratio: Distance the airplane travels in relation to the altitude it loses
      i. Ex: Glide ratio is 11:1, or 11,000’ forward while descending 1,000’ in the DA20
         a. Can glide about 2-miles for every 1,000’ AGL (lose about 500’ per mile)
      ii. Provides an estimate of how far you can fly
      iii. Any increase or decrease from best glide reduces the glide ratio
   C. Best Glide & Weight
      i. L/D determines the distance the airplane can glide, not weight
      ii. If the pilot maintains the proper speed, changes in weight don’t affect the best glide angle or distance flown
      iii. However, a heavier plane needs to fly at a higher airspeed to obtain the same glide ratio
         a. The heavier plane will travel the same distance but do it in a shorter time
      iv. Many aircraft publish glide speeds that increase based on weight

D. Best Glide & Wind AI.XII.B.K2c
   i. With a tailwind, the airplane glides farther because of the higher groundspeed
   ii. With a headwind, the airplane does not glide as far because of the lower groundspeed
E. Best Glide & Configuration
   i. When drag increases, the airplane must be pitched down to maintain airspeed (no longer at L/D_{MAX})
   ii. Lower pitch = a steeper glidepath and reduces distance traveled
   iii. To maximize distance traveled, minimize drag-producing components
      a. Flaps, landing gear, cowl flaps, etc.
F. Minimum Sink Speed AI.XII.B.K2b
   i. Airspeed use to maximize the time that the airplane remains in flight
      a. Results in losing altitude at the lowest rate (lowest vertical speed)
   ii. Less distance traveled versus best glide airspeed
   iii. Useful when time in flight is more important than distance flown (ex: ditching at sea)
   iv. Not often published but generally a few knots less than best glide airspeed
G. Since glides are often performed close to the ground and, in this case without power, accuracy and proper technique and habits are especially important
   i. Cardinal Rule: Do not attempt to “stretch” a glide by increasing back pressure/slowing below best glide
   ii. Any speed other than best glide reduces distance traveled

2. ABC(D) Checklist AI.XII.B.K1

A. **A**VIATE: The first reaction should be to immediately establish best glide speed and fly the airplane
   i. Flying the airplane is the highest priority
   ii. Establish and maintain the best glide speed
      a. Maintain altitude until airspeed slows to best glide
         - Once stabilized, trim for best glide speed
   iii. Eagerness to get down is one of the most common faults during simulated emergency landings
      a. Pilots forget about speed and arrive at the edge of the field too fast for a safe landing
      b. Too much speed is just as dangerous as too little
   iv. Airspeeds other than the best glide airspeed result in diminished glide performance
      a. Know the general pitch attitude required for the best glide speed
         - Although this attitude can vary start there and make small adjustments
         - Trim the airplane to maintain the speed and reduce workload in a busy situation
      b. If airspeed is too fast, gently raise the nose, allow airspeed to settle and trim
      c. If airspeed is too slow, gently lower the nose, allow airspeed to settle and trim
   v. Keep in mind:
      a. Aircraft are often designed to compensate for some amount of p-factor and slipstream
         - These effects disappear during a glide
         - Slight left rudder may be necessary to minimize drag to the greatest extent
      b. Larger than normal control movements are necessary due to reduced airflow over the control surfaces
B. **B**EST Landing Spot: Select the best landing spot and immediately turn toward it
   i. The pilot’s choice of emergency landing sites is governed by:
      a. The route selected during preflight planning
      b. The height above the ground when the emergency occurs
      c. Excess airspeed (excess airspeed can be converted into distance and/or altitude)
   ii. If possible, find a nearby airport
      a. If GPS is available, use the Nearest page to decide whether the airport can be reached
         - *Glide ration is 11:1 (DA20) – ~2-mile glide for every 1,000’ AGL (lose about 500’ per mile)
   iii. If an airport is not available or practical, select a field that is within glide distance

a. Check in front, behind, and to BOTH sides of the airplane
b. Preferably hard packed, long, smooth, and with no obstacles, especially at the approach end
   - Terrain's appearance from altitude can be very misleading. For this reason, the pilot should not hesitate to discard the original plan for one that is better upon closer inspection
c. As a general rule, the pilot should not change their mind more than once
   - A well-executed crash in poor terrain can be less hazardous than an uncontrolled touchdown elsewhere

iv. Note the wind direction (blowing fields, dust, water, smoke, etc. can indicate direction) and speed
   a. Attempt to land into the wind, although factors may dictate otherwise
      - Insufficient altitude, ground obstacles, terrain, etc.
      - A tailwind landing (high groundspeed) could be hazardous, extending the landing distance
   b. Be aware of any crosswind based on the selected landing area
      - Take note of the crab necessary to maintain your course
         a The steeper the crab, the stronger the wind
         b Compensate for this on landing – a severe side load on a soft field could be catastrophic

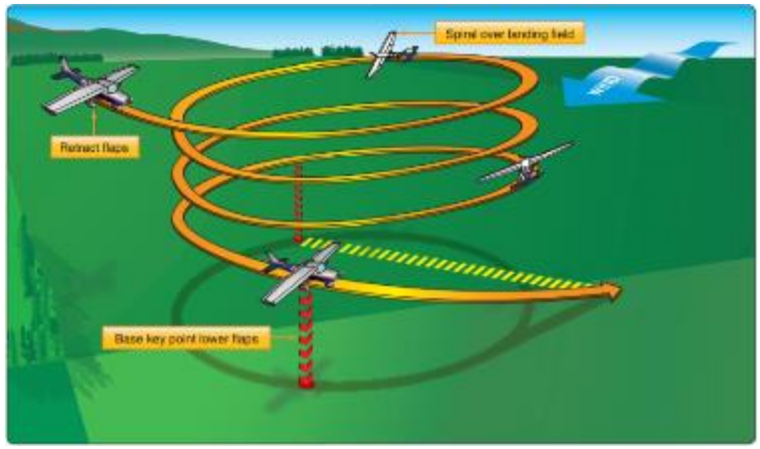
v. Be aware of traffic
   a. Always continue to clear for traffic

C. Emergency **C**HECKLISTs
   i. *Restart
      a. Mixture: RICH, Fuel Valve: IN, Ignition: BOTH, Fuel Pump/Primer: ON, Throttle ¾-inch open
         - If prop is stopped (common occurrence), Ignition Switch: START
   ii. *Troubleshoot
      a. Mixture: RICH, Alternate Air: OPEN, Fuel Valve: OPEN, Fuel Pump: ON, Ignition: CYCLE L/R
      b. Check the systems to decipher the problem (You can usually recover from the problem)
   iii. It is important to determine the reason for the loss of power and attempt to restart the engine
      a. If the reason for failure can be determined, it is possible the engine can be restarted
         - The pilot will also have to make the decision to continue the flight, divert to another airport, or continue the emergency landing
      b. Ex: If the electric fuel pump restarts the engine, it is likely the engine driven pump failed. The pilot could consider proceeding to a nearby airport. Whereas, if there is an oil leak, and the engine cannot be safely restarted/expected to run, the emergency landing should be continued
   iv. Can add **D**istress call
      a. When able, inform ATC or Guard

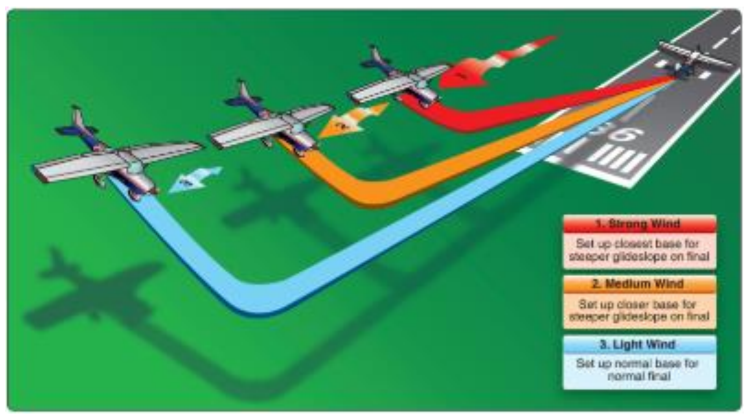
3. Emergency Approach

A. Planning the Approach
   i. Planning of the approach should be governed by the following:
      a. Wind direction and velocity
      b. Dimensions and slope of the chosen field
      c. Obstacles in the final approach path
   ii. All three factors are seldom compatible, when compromises have to be made, aim for a combination that permits a final approach with some margin for error in judgement or technique

a. Ex: Overestimated glide distance may tempt a pilot to stretch the glide across obstacles on the approach path. For this reason, it could be better to plan the approach over an unobstructed area, regardless of wind – a collision at the end of a ground roll is safer than at flying speed



B. Proceed directly to the selected landing area
  i. Goal: end up on downwind, abeam the landing point at a normal traffic pattern altitude for the area
  ii. If you are higher than pattern altitude, circle over the approach end, descending to pattern altitude
    a. *A complete 360º turn loses 500’ - 600’
    b. Use any combination of normal gliding maneuvers (wings level to spiral) to arrive at the desired position/altitude
    c. Make the turns in the same direction you intend to fly the pattern
  iii. RM: Following or changing the flight path to the landing area AI.XII.B.R2
    a. Adjustments may be made as conditions change
    b. Best practice is to go directly to the landing area and circle overhead, with a plan to enter the pattern
C. Divide attention between flying and accomplishing the checklists
  i. Maintain reference to the landing field and best glide speed while performing the checklists
D. Adjust the pattern based on altitude, wind conditions, etc. to safely reach the landing area AI.XII.B.K3
  i. Goal: make the pattern and approach as normal as possible
    a. Corrections will have to be made throughout (too high, too low, when to configure, etc.)
  ii. The turn to the base leg and final is positioned as needed based on altitude, wind, obstructions, etc.



    a. A strong headwind would require a closer base leg. A tailwind would require a farther out base
    b. Too much altitude may require a delayed base, too little altitude may require an early turn
    c. If very low, the base leg can be removed, and the pilot can proceed directly to the landing area
  iii. Adjust as necessary based on altitude and glide angle to reach the landing area. Options include:

Too High	Too Low
• Extend the pattern	• Tighten the pattern
• S-turn	• Proceed direct to landing
• Configure early	• Delay configuration
• Slip	• Maintain best glide

E. Stable Approach AI.XII.B.K4
  i. The more stable the approach, the more predictable the approach
    a. Applies to best glide/glide ratio as well as altitude lost while circling
      • Estimates are only as accurate as your flying (improper airspeed = unreliable distances/altitudes)
  ii. Flying the airplane is the highest priority
F. RM: Configuration AI.XII.B.R4

i. Intent is to land in a normal landing configuration (emergency permitting)
ii. Flaps will be gradually lowered based on the conditions/situation/airplane performance
a. Have a standard position to lower the flaps and adjust based on the day
- Too high: Configure earlier (or delay configuration and slip, vary the base leg, etc.)
- Too low: Delay configuration (tighten the base leg and/or turn to final)
b. Once flaps are lowered, they should not be retracted
c. Landing flaps should only be lowered once the landing area is assured

G. The pattern that works for one emergency approach and landing likely won't work for the next one
i. Always be aware of, and adjust for, the aircraft's position in relation to the landing area

4. Contacting ATC

A. If already on frequency with ATC, transmit "Mayday, mayday, mayday"
i. If not on a frequency, use guard on 121.5
ii. Let them know who you are, where you are, and what you're doing
a. Mayday, mayday, mayday, Diamond 3RT, 5 miles North of XYZ VOR, engine failure, making an emergency landing 2 miles to the N of current position
b. They'll likely also want to know fuel and souls onboard
iii. The radios will likely be kept on until just before landing. Keep ATC apprised of the situation/plan

B. ATC Services AI.XII.B.K6
i. Priority
a. The frequency is basically yours, whatever you need
- If the frequency is congested, it's possible they'll switch to another frequency just for you
b. You become their primary focus
ii. Aircraft Separation
a. Any other potentially hazardous aircraft will be moved out of your way
iii. Advice
a. Nearby airports
iv. Emergency Response
a. If a towered airport, ATC will coordinate with the tower to prepare for the emergency landing
b. If no fire/rescue services are available, ATC will coordinate with local emergency response

C. If time and conditions permit, squawk emergency - 7700

5. Emergency Landing

A. If the engine cannot be restarted, complete the Emergency Landing Checklist
i. *Fuel Valve: OUT, Mixture: CUT-OFF, Ignition: OFF - To avoid a fire
ii. Keep the electrical equipment on as long as necessary to make radio calls, use the flaps, etc.

B. Gear
i. Gear and flaps should only be lowered after landing is assured
ii. Gear down can provide better protection in the case of stumps, rocks, or other large obstacles
iii. If the field is excessively soft, wet, short, or snow covered, a gear up landing may be safer
a. Eliminates the possibility of the airplane nosing over if the wheels dig in

C. If practical, hold the wheels off to allow for a gentle touchdown, like a soft field landing
i. At this point, the safety of the passengers is the only concern, the airplane does not matter

6. RM: Descent Factors AI.XII.B.R1

A. Altitude
i. Dictates the distance the aircraft can travel
a. Use AGL, not MSL
b. Know approximate distance traveled at best glide per 1,000' – apply to the situation
ii. Goal is to put the aircraft at a normal pattern altitude at a normal key position
a. Adjust the path, descent, spiral as necessary to arrive at this location and altitude

B. Wind
   i. During the approach
      a. It can influence glide distance (headwind vs tailwind vs crosswind)
         - Headwind decreases glide distance; Tailwind increases glide distance
      b. The stronger the wind on final, the closer the base leg needs to be to make a normal approach
   ii. Tailwind
      a. A tailwind increases the runway required for landing
         - Only land with a tailwind if it is the safest option
      b. The flight manual will publish a maximum tailwind for landing
         - If possible, do not exceed this limit
   iii. Maximum Demonstrated Crosswind Component
      a. If possible, don't exceed it as the plane may not be able to remain with the confines of the landing area

C. Terrain & Obstructions
   i. Be especially cautious of terrain/obstructions during an emergency approach & landing
   ii. Without an engine, there may not be enough energy to clear the terrain

D. Available Landing Distance
   i. Be familiar with the landing distance required for an emergency approach and pick a suitable landing area
      a. The landing distance at off airport landing areas will have to be estimated from the air
      b. Be familiar with the approximate distance required and what that looks like on the ground

7. Emergency Locating Devices AI.XII.B.K5

A. ELT: Small, self-contained radio transmitter that will automatically, upon impact, transmit an emergency signal
   i. Transmits on 121.5, 243, and/or 406 MHz
   ii. Built into the airplane

B. Numerous private companies produce emergency locating devices that can be carried on oneself
   i. Basic Personal Locator Beacons (PLBs)
      a. Transmit on 406 MHz, track your location within about 100 meters
      b. National Oceanic and Atmospheric Administration (NOAA) monitors the system and PLB registration
         - Any distress signal will identify the owner with personal info
   ii. Satellite Messengers
      a. Range of capabilities – GPS functions, text communications, custom apps to link to your phone/tablet

8. Mental Attitude

A. The survival records favor pilots who maintain their composure and know how to apply the general concepts and procedures developed through the years. The success of an emergency landing is as much a matter of the mind as of skills
   i. Remember, "we don't rise to the level of our expectations; we fall to the level of our training"

9. Common Errors AI.XII.B.K7

A. Improper airspeed control
B. Poor judgment in the selection of an emergency landing area
C. Failure to estimate the approximate wind speed and direction
D. Failure to fly the most suitable pattern for existing situation
E. Failure to accomplish the emergency checklist
F. Undershooting or overshooting selected emergency landing area

10. RM: **Hazards**

NOTE: The remaining RM concepts shown below are organized in this order in a document at the end of the section. Just (hold control &) click the top link, or whichever one you need, and continue through the content.

A. XII. RM Concepts – Low Altitude Maneuvering AI.XII.B.R5
B. XII. RM Concepts – Collision Hazards AI.XII.B.R3
C. XII. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.XII.B.R6

Conclusion:

Brief review of the main points

During an emergency approach and landing, it is important that the pilot choose the most suitable landing area within gliding distance and properly configure the airplane to maintain the best glide airspeed and attempt to regain power. If regaining power is not possible, the airplane should be set up for an emergency landing and an emergency approach and landing should be executed into the wind as precisely as possible. The pilot should announce the emergency and squawk 7700 as practicable. Flying the aircraft is the number one priority.

Private & Commercial Pilot ACS Skills Standards

1. Establish and maintain the recommended best glide airspeed, ±10 knots.

XII.C. Systems & Equipment Malfunctions

Select the aircraft Systems and Equipment Malfunctions lesson from the Navigation Pane, or use the links below:

GENERIC
Generic Aircraft Malfunctions

CESSNA
Cessna 152
Cessna 172S G1000

CIRRUS
Cirrus SR20

DIAMOND
Diamond DA20
Diamond DA40

PIPER
Piper Archer II (PA-28-181)
Piper Archer III (PA-28-181)
Piper Arrow (PA-28R-201)

XII.C. Generic

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of emergency procedures and be able to explain the proper procedures for certain situations based on the ACS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Malfunction Procedures 2. Power Loss 3. Electrical Malfunction 4. Vacuum/Pressure Malfunctions 5. Pitot Static Malfunction 6. EFD Malfunction 7. Flap Malfunction 8. Hydraulic Malfunction 9. Landing Gear Malfunction 10. Inoperative or "Runaway" Trim 11. Smoke & Fire 12. Door or Window Opening in Flight 13. Pressurization Malfunction 14. Other Malfunctions 15. Common Errors 16. Hazards
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can understand problems and why they may occur in the airplane. The learner also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve the knowledge and procedures to handle problems that may occur in the airplane.

Why

The key to successful management of an emergency, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

Note: This lesson provides generic procedures & malfunction discussions. Always follow the POH procedures.

1. **Malfunction Procedures (MATL)**
   - A. Maintain Aircraft Control
     - i. Fly the airplane
     - ii. Get to a safe flight state (straight-and-level, etc.)
     - iii. Trim the aircraft and turn on the autopilot, if possible
     - iv. Maintaining control continues throughout the malfunction
       - a. Do not let the issue, checklists, etc. distract from flying the airplane
       - b. Divide attention between flying and checklists/procedures
     - v. RM: Distractions can lead to an undesired aircraft state (UAS) AI.XII.C.R4
       - a. Can quickly amplify the malfunction already being dealt with
       - b. The malfunction could also be the reason for the UAS
       - c. Maintaining control is the top priority – in the case of an UAS:
         - Push, Roll, Thrust, Stabilize as required
         - Understand the specific malfunction may limit or prevent recovery
           - a Further emphasizes the need to maintain control
   - B. Analyze the Situation
     - i. Indications, lights, sounds, visual (i.e., smoke, leaks, fire, etc.), smells, etc.
     - ii. Use all available information to determine the issue
   - C. Take the Proper Action
     - i. Apply any memory items
     - ii. RM: Checklist usage – Use the appropriate checklist from the POH AI.XII.C.R2
       - a. Checklist is the safest, most effective way to handle the problem
     - iii. Don't go rogue and make up your own procedure/guess
       - a. Potential to not fix the problem and/or cause other problems
   - D. Land, as conditions require/permit
     - i. Based on the emergency, decide on a landing area (divert, field, ditching, etc.)

ii. This may have to occur in conjunction with the checklist(s)

2. Power Loss AI.XII.C.K1

A. Rough running engine:

Possible Causes	Corrective Action
Improper mixture	Adjust mixture for smooth op
Defective ignition or valves	Consult maintenance personnel
Detonation / preignition	Reduce power, enrich mixture, open cowl flaps, land as soon as practical
Induction air leak	Reduce power. Consult maintenance
Plugged fuel nozzle	Reduce power. Consult maintenance
Excessive fuel pressure / fuel flow	Lean mixture
Induction Icing	Leave icing conditions, use alternate air source

A. Oil Pressure Malfunctions
- i. High Oil Pressure
  - a. Possible Cause - Cold oil or possible internal plugging
  - b. Corrective Action - If cold, allow the engine to warm, if not, reduce power and land ASAP
- ii. Low Oil Pressure
  - a. Possible Cause – Broken pressure relief valve, insufficient oil, burned out bearings
  - b. Corrective Action – Land as soon as possible or feather the propeller and stop the engine (multi-engine)
- iii. Fluctuating Oil Pressure
  - a. Possible Cause – Low oil supply, loose oil lines, defective pressure relief valve
  - b. Corrective Action – Land as soon as possible or feather propeller and stop engine (multi-engine)

B. Engine Overheat
- i. The oil temperature gauge is the primary instrument in determining if the engine is overheating

C. Fuel Starvation
- i. Normally indicated by a rough running engine, and can be caused by blocked lines or empty tanks
- ii. In general, turn on boost pumps, switch tanks, verify fuel is on, adjust mixture

3. Electrical Malfunction AI.XII.C.K2a

A. Electrical Power
- i. Generally, power comes from a generator or alternator
- ii. If the generator/alternator fails, typically a battery provides power for a limited amount of time

B. Battery Time
- i. The higher the amperage load (electrical draw) on the battery, the faster the energy gets consumed
  - a. Ex: 25-amp hour battery can produce 5 amps per hour for 5 hours
    - Increasing to 10 amps, it may only last 2 hours
    - 40 amps may discharge the battery in 10-15 mins
- ii. Battery condition matters
  - a. Over time, power is reduced due to internal resistance
- iii. Very important to shed non-essential loads to provide maximum time

C. Consumers
- i. See picture to right for average amperage
- ii. Gear and flaps use significant amounts of power
  - a. Using them may result in a total loss of power

D. Procedures
- i. Follow the applicable checklist(s) in the POH

Electrical Loads for Light Single	Number of units	Total Amperes
A. Continuous Load		
Pitot Heating (Operating)	1	3.30
Wingtip Lights	4	3.00
Heater Igniter	1	1-20
**Navigation Receivers	1-4	1-2 each
**Communications Receivers	1-2	1-2 each
Fuel Indicator	1	0.40
Instrument Lights (overhead)	2	0.60
Engine Indicator	1	0.30
Compass Light	1	0.20
Landing Gear Indicator	1	0.17
Flap Indicator	1	0.17
B. Intermittent Load		
Starter	1	100.00
Landing Lights	2	17.80
Heater Blower Motor	1	14.00
Flap Motor	1	13.00
Landing Gear Motor	1	10.00
Cigarette Lighter	1	7.50
Transceiver (keyed)	1	5-7
Fuel Boost Pump	1	2.00
Cowl Flap Motor	1	1.00
Stall Warning Horn	1	1.50

** Amperage for radios varies with equipment.
In general, the more recent the model, the less amperage required.
NOTE: Panel and indicator lights usually draw less than one amp.

a. Reduce electrical load
b. Fly on the backup instruments

ii. Generic Steps
a. Shed all but the most necessary electrical equipment
- Can vary based on the situation (day/night, VMC/IMC)
b. Notify ATC immediately – Request vectors for landing at the nearest suitable airport
c. Expect a no-flap landing and manual gear extension

4. Vacuum/Pressure Malfunctions AI.XII.C.K2b

A. What's Lost?
i. Heading Indicator, Attitude Indicator, and/or Turn Coordinator
ii. Traditionally, turn coordinators use a different power source than the heading / attitude indicators
a. Ex. Vacuum for the attitude and heading gyros, and electric for the turn coordinator
b. If the heading & attitude indicators fail, the turn coordinator is still usable, and vice versa

B. Failure results from a loss of the suction or pressure source (vacuum failure)
i. As the gyroscopes slow down, they will begin to wander, displaying incorrect information
ii. Can be slow and insidious

C. Many small aircraft do not have a warning system for vacuum failure
i. Look for vacuum failure indications – monitor the vacuum pressure gauge

D. Compare the Attitude Indicator with the Turn Coordinator and VSI
i. Along with providing pitch / bank information, this compares the static, suction, and electric systems
ii. Identify the failed component(s) and use the remaining functional instruments to maintain control

E. Assess the situation - when and where to land may vary based on the conditions and failure(s)
i. Day VMC with backup instruments may allow the pilot to return to their home field
ii. Night, reduced visibility, or minimal horizon may require an emergency and landing at the closest field

5. Pitot Static Malfunction AI.XII.C.K2c

A. General
i. Errors in the ASI and VSI almost always indicate a pitot blockage, static blockage, or both
ii. Moisture, ice, dirt, insects, etc. can cause a blockages
iii. Always preflight the pitot tube and static ports

B. Blocked Pitot System
i. Pitot system measures the difference between ram air pressure in the pitot tube and static air pressure from the static port
a. Static pressure is vented to instrument casing
b. Ram air is connected to a diaphragm in the case

ii. Ram air blocked, with drain hole open
a. Air already in the system vents through the drain hole and remaining pressure in the pitot tube drops to match the outside (static) air pressure
b. Airspeed decreases to zero as ram air pressure and static pressure become equal
- Not an instantaneous drop, but happens quickly

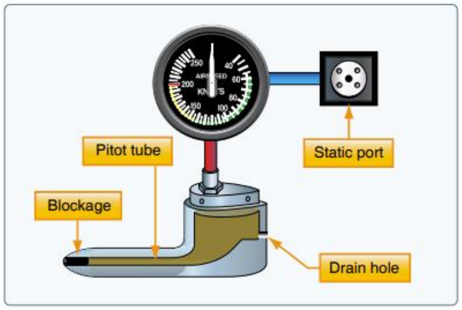


Figure 8-9. *A blocked pitot tube, but clear drain hole.*

iii. Ram air blocked, and drain hole blocked
a. Big Picture
- Airspeed indicator acts like an altimeter

- Ram air pressure in the pitot tube is trapped
    - a Accelerating/decelerating does not affect indications
- Static pressure changes with altitude

b. In a climb
- Ram air pressure remains constant
- Static pressure decreases
- Diaphragm expands, just like would happen with an increase in ram air pressure/acceleration
- Airspeed increases as altitude increases

c. In a descent
- Ram air pressure remains constant
- Static pressure increases
- Diaphragm contracts, just like would happen with a decrease in ram air pressure/deceleration
- Airspeed decreases as altitude decreases

d. Airspeed acts like an altimeter, increasing in a climb and decreasing in a descent

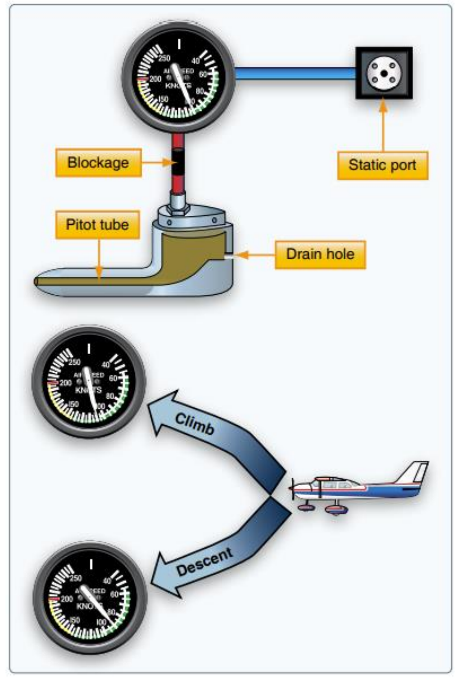


Figure 8-10. *Blocked pitot system with clear static system.*

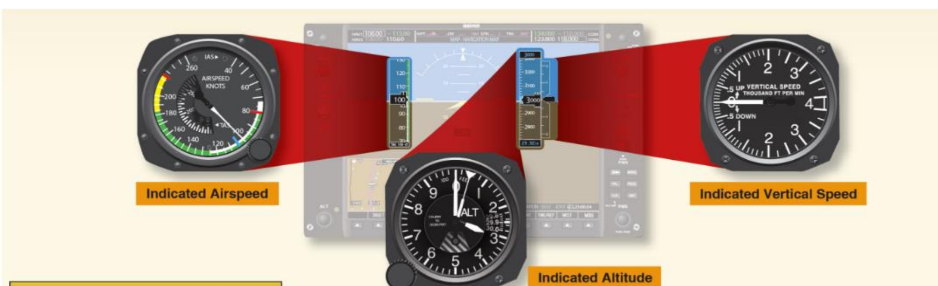
C. Blocked Static System

i. Static system blocked, with pitot tube open

a. Airspeed operates but is inaccurate
- When above the altitude where the static port(s) were blocked, airspeed indicates lower than actual
    - a Trapped pressure is higher than normal for the altitude
- When at a lower altitude, airspeed indicates higher than actual
    - a Trapped pressure is lower than normal for that altitude

b. Altimeter freezes at the altitude where the block occurred

c. Vertical Speed shows a continuous zero indication



Effect of Blocked Pitot/Static Sources on Airspeed, Altimeter, and Vertical Speed Indications	Indicated Airspeed	Indicated Altitude	Indicated Vertical Speed
Pitot source blocked	Increases with altitude gain, decreases with altitude loss.	Unaffected	Unaffected
One static source blocked	Inaccurate while sideslipping; very sensitive in turbulence.		
Both static sources blocked	Decreases with altitude gain, increases with altitude loss.	Does not change with actual gain or loss of altitude.	Does not change with actual variations in vertical speed.
Both static and pitot sources blocked	All indications remain constant, regardless of actual changes in airspeed, altitude, and vertical speed.		

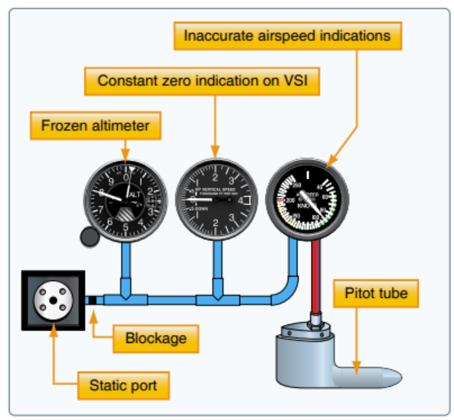


Figure 8-11. *Blocked static system.*

D. Alternate Static Source

i. Provides alternate source of static pressure in the case the primary becomes blocked

ii. Normally inside the flight deck

a. Cabin pressure is lower than exterior pressure due to venturi effect of air flowing around the fuselage

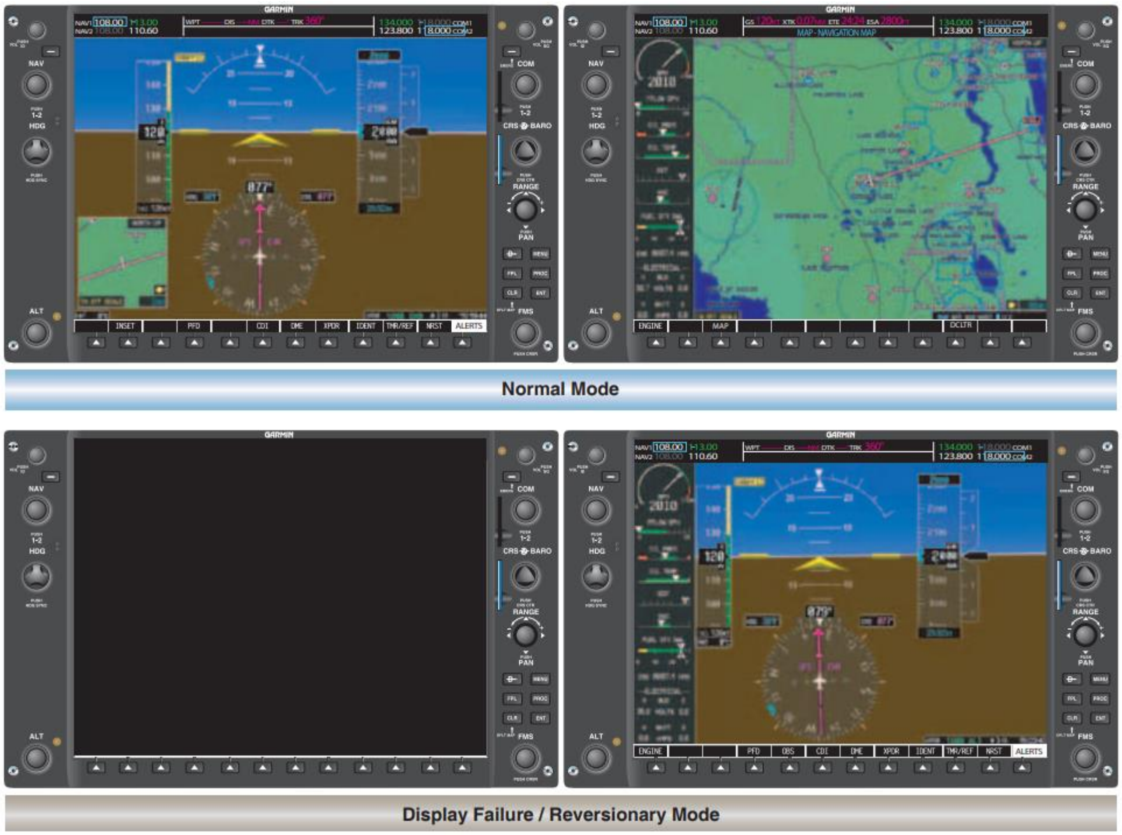
iii. Instrument indications when the alternate static source is used:

a. Altimeter indicates slightly higher than actual

b. Airspeed indicates greater than actual
c. Vertical speed shows a momentary climb and then stabilizes if altitude is constant

6. Electronic Flight Display (EFD) Malfunction AI.XII.C.K2d

A. In the case of an EFD failure, the system reverts to a composite, reversionary mode
  i. Moving map is eliminated
  ii. PFD and engine instruments are combined on the remaining screen



B. Pilots often become overly reliant on the moving map
  i. What should be a supplementary source of data becomes a primary navigation tool
  ii. Significant loss of situational awareness if the pilot is not prepared for this failure

C. Stay Prepared
  i. Follow the flight on an enroute chart while monitoring the moving map
  ii. Have a Chart Supplement to prevent losing access to airport information

7. Flap Malfunction AI.XII.C.K2e

A. Total Flap Failure (no flap approach and landing)
  i. Requires substantially more runway than normal (as much as 50% more)
  ii. Losing altitude is more difficult so a wider, longer pattern may be necessary
  iii. Flown in a relatively nose-high attitude compared to flaps extended
    a. On final, this can make it difficult to see the runway
    b. Can lead to errors in judgement of height/distance and cause the perception the plane is close to a stall
  iv. Landing
    a. Airplane is slightly less stable in pitch and roll axes with power reduced and flaps retracted
    b. Tend to float during roundout
    c. Don't force the plane onto the ground
    d. Don't flare excessively as it risks a tail strike

B. Asymmetric (Split) Flap
   i. A situation in which one flap deploys or retracts while the other remains in position
   ii. Indicated by a roll toward the wing with the least flap deflection
   iii. Countered with opposite aileron
      a. Yaw caused by the additional drag on the extended flap side requires opposite rudder
      b. Almost full aileron may be necessary at reduced airspeeds to maintain wings level
         - Do not attempt to land with a cross-wind from the side of the deployed flap
   iv. Be aware of the differing stall speeds of each wing
      a. The wing with the retracted flap will stall earlier - possible cross-controlled stall condition
   v. Approach and landing should be flown at a higher-than-normal airspeed

8. Hydraulic Malfunction AI.XII.C.K2e

A. If the hydraulic pump were to fail, there are alternate means to raise/lower the gear
   i. Some airplanes will automatically lower the gear

9. Landing Gear Malfunction AI.XII.C.K2e

A. Alternate gear extension procedure
   i. If this does not solve the problem, a gear up landing is required
B. Considerations
   i. Airport with crash and rescue facilities
   ii. A smooth, hard runway surface tends to cause less damage than a rough, unimproved grass strip
      a. The hard surface does create sparks that could ignite fuel
         - Can request for the runway to be foamed, if available
   iii. Burn off excess fuel
      a. Reduced landing speed and chance of fire
      b. If the malfunction is limited to one leg, consume as much fuel from that side as practicable
         - Reduced weight on that side allows you to delay contact with the surface until the last moment
            a Reduced impact speed = reduced damage
C. Landing the Airplane
   i. One Leg Retracted
      a. Land in a nose-high attitude with wings level
      b. As airspeed slows, apply aileron to keep the unsupported wing airborne as long as possible
      c. After touchdown, the airplane will veer strongly in the direction of the faulty gear leg/dragging wing
         - Use full opposite rudder and aggressive braking to maintain some degree of directional control
      d. On a narrow runway, or one with ditches/obstacles on the edges, landing with all gear up may be safer
   ii. Nose Wheel Retracted
      a. Hold the nose off the ground until almost full-up elevator is applied
      b. Release back pressure to allow the nose to slowly settle to the surface
         - Applying full back pressure results in the nose abruptly dropping to the surface
            a Can result in burrowing and/or additional damage
         - Try to gently set the nose on the ground
      c. Do not apply brakes unless necessary to avoid a collision with obstacles
   iii. Main Gear Retracted (Nose extended)
      a. Initial contact should be made on the aft fuselage with a nose high attitude
         - Helps to prevent porpoising and/or wheelbarrowing
      b. Allow the nose-wheel to gradually touchdown
      c. Use nose-wheel steering as necessary

10. Inoperative or "Runaway" Trim AI.XII.C.K2f

A. Grip the controls and maintain control of the plane while disengaging the electric trim system

        i. Disengage button, circuit breaker, etc.
    B. If the reason for the runaway trim is obvious and has been resolved, engage the breaker

11. Smoke & Fire AI.XII.C.K3

- A. In any fire, it is essential the source is discovered first
    - i. Identifying the source allows the pilot to fight the fire most effectively
        - a. Identify/shutdown the faulty component, use the extinguisher effectively, run the proper checklist, etc.
- B. In-Flight Smoke/Fire
    - i. Engine Fire
        - a. Usually caused by a failure allowing a combustible substance to contact a hot surface
        - b. Indicated by smoke / flames from cowling; and / or discoloration, bubbling, melting of cowling
        - c. Unless the POH says otherwise, 1st step should be to shut off fuel
        - d. If the flames are put out, do not attempt to restart the engine
        - e. Perform an emergency landing
        - f. Keep in mind:
            - There may be severe structural damage and control could be lost at any time
            - Airplane may still be on fire and susceptible to explosion
            - Airplane is expendable and the only thing that matters is the safety of those onboard
    - ii. Electrical Fires
        - a. First indication is usually the distinct odor of burning insulation
        - b. Try to identify the problem by checking circuit breakers, lights, instruments, avionics
            - If it cannot be detected, the battery master and generator should be turned off
                - a Any materials which have been ignited may continue to burn
        - c. If power is essential for the flight, attempt to identify / isolate the faulty circuit:
            - Electrical master off, then all individual electrical switches off
            - Electrical master on
            - Turn on electrical switches one at a time, waiting after each switch to check for signs of fire
                - a Turn off / do not use any equipment that restarts the fire. Other equipment can be used
    - iii. Cabin Fires
        - a. Usually result from smoking, electrical system malfunctions, and heating system malfunctions
        - b. Two immediate demands:
            - Attacking the fire, and getting the airplane safely on the ground as quickly as possible
        - c. In general, identify and shutdown the cause of the fire
        - d. Smoke can often be cleared by opening air vents – only after using the fire extinguisher
            - If smoke increases, immediately close them
        - e. Windows can also be used to help clear smoke
        - f. Use oxygen if the smoke is severe; initiate an immediate descent
- C. Ground Smoke / Fire
    - i. Engine Fire / Smoke - Shut down the engine, turn off the electrics and evacuate the airplane
    - ii. Electrical Fire / Smoke - Immediately turn off the master switch, and shutdown the engine
        - a. Use the fire extinguisher and evacuate as necessary

12. Door or Window Opening in Flight AI.XII.C.K5

- A. Follow the POH procedures. In general, adhere to the following:
    - i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
    - ii. Do not rush to land (climb to normal pattern altitude, fly a normal pattern, make a normal landing)
    - iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
    - iv. Most doors will not stay open, they will usually bang open then settle partially closed
        - a. A slip toward the door may open it wider, and a slip away may push it closed

13. **Pressurization Malfunction** AI.XII.C.K4
    A. Descend or use supplemental oxygen (emergency descent)
    B. Hypoxia is the primary danger of decompression
14. **Other Malfunctions** (supplemental oxygen, deicing, etc.) AI.XII.C.K4
    A. Reference the POH and/or user's manual for specific procedures
15. **Common Errors** AI.XII.C.K6
    A. Inaccurate diagnoses of the malfunction
    B. Use of an improper checklist/procedure
    C. Lack of control throughout the malfunction
    D. Fixation on the malfunction at the expense of the aircraft & safe flight
16. RM: **Hazards**
    A. Startle Response AI.XII.C.R1
        i. Uncontrollable, automatic muscle reflex, raised heart rate, blood pressure, etc. elicited by exposure to a sudden intense event that violates a pilot's expectations
        ii. Protect against startle response through scenario-based training incorporating realistic distractions
        iii. The pilot should react in a calm, controlled manner and:
            a. Maintain aircraft control
            b. Analyze the situation
            c. Take the proper action
            d. Land, as conditions require/permit
        iv. Reactions or inputs outside of checklists may likely aggravate the situation

NOTE: The remaining RM concept shown below is in a document at the end of the section. Just (hold control &) click the link and continue through the content.

    B. XII. RM Concepts – Distractions, SA & Disorientation, Task Prioritization AI.XII.C.R3

Conclusion:

Brief review of the main points

Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. DA20

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Smoke, Fire, or both, during Ground or Flight Operations 2. Rough Running Engine or Partial Power Loss 3. Loss of Engine Oil Pressure 4. Fuel Starvation 5. Engine Overheat 6. Hydraulic Malfunction 7. Electrical Malfunction 8. Induction Icing 9. Door or Window Opening in Flight 10. Inoperative or "Runaway" Trim 11. Flap malfunction 12. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	4. Participate in discussion 5. Take notes 6. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

*The following procedures are from the DA20 POH, changes will have to be made for your aircraft

1. **Smoke, Fire, or Both, During Ground or Flight Operations**
   A. In-Flight Smoke/Fire - In any fire, it is essential the source is discovered first
      i. Engine Fire
         a. Usually caused by a failure allowing a combustible substance to contact a hot surface
         b. Checklist

• Shut off the fuel supply to the engine	• Airspeed: 73 knots
a Fuel Shut-Off Valve: CLOSED	• Fuel Pump: OFF
• Cabin Heat: CLOSED	

         c. If the flames are put out, do not attempt to restart the engine
         d. Perform an emergency landing
         e. Keep in mind that
            - There may be severe structural damage and control could be lost at any time
            - The airplane may still be on fire and susceptible to explosion
            - The airplane is expendable and the only thing that matters is the safety of those onboard
      ii. Electrical Fires
         a. Indication is usually the distinct odor of burning insulation
         b. Checklist

• GEN/BAT Master: OFF
• Cabin Air: OPEN
• Fire Extinguisher: Use only if smoke development continues

         c. If the fire is extinguished and electric power is required to continue the flight:

• Avionics Master: OFF
• Electrically Powered Equipment: OFF
• Restore electrical power systematically allowing time to monitor the system voltmeter and amp meter-Watch carefully for smoke

a Circuit Breakers: PULL ALL	f Circuit Breakers: Push AVIONICS & AVIONICS MASTER

b	Circuit Breakers: PUSH BATTERY	g	Avionics Master: ON
c	GEN/BAT Master: ON BAT (½ only)	h	Circuit Breakers: Activate systems as required
d	Circuit Breakers: Push GEN & GEN CONTROL	i	Radio: ON
e	GEN/BAT Master Switch: ON	j	Land ASAP

d. Try to identify the faulty circuit by checking circuit breakers, lights, instruments, and avionics
- If it cannot be detected, the battery master switch and generator should be turned off
    a However, any materials which have been ignited may continue to burn

e. If there is smoke in the flight deck, open the windows

iii. Cabin Fires

a. Usually result from:
- Careless smoking on the part of the pilot and/or passengers
- Electrical system malfunctions
- Heating system malfunctions

b. Two immediate demands:
- Attacking the fire
- Getting the airplane safely on the ground as quickly as possible

c. Checklist

• GEN/BAT Master: OFF	• Cabin Heat: CLOSED
• Cabin Air: OPEN	• Fire Extinguisher: As Required
a If smoke increases, close immediately – possible fire in heating system/baggage	• Land ASAP

B. Ground Smoke/Fire

i. Engine Fire/Smoke

a. Checklist

• Fuel Shutoff Valve: CLOSED	• GEN/BAT Master: OFF
• Cabin Heat: CLOSED	• Ignition: OFF
• Mixture: IDLE CUTOFF	• Evacuate Immediately

ii. Electrical Fire/Smoke

a. If smoke in the cabin indicates an electrical fire, immediately turn off the master switch

b. Checklist
- GEN/BAT Master: OFF
- In Engine is running

a	Throttle: IDLE	d	Ignition: OFF
b	Mixture: IDLE CUTOFF	e	Canopy: OPEN
c	Fuel Shutoff Valve: CLOSED	f	Fire Extinguisher: As Required

2. Rough Running Engine or Partial Power Loss

A. Checklist

i.	Mixture: FULL RICH	v.	Ignition: CYCLE, L - BOTH - R – BOTH
ii.	Alternate Air: OPEN	vi.	Throttle: AT PRESENT POSITION
iii.	Fuel Shutoff: OPEN	vii.	If no improvement, reduce the throttle to minimum required power and land ASAP
iv.	Fuel Pump: ON		

3. Loss of Engine Oil Pressure

A. High Oil Pressure

i. Possible Cause - Cold oil or possible internal plugging

ii. Corrective Action - If cold, allow the engine to warm, if not, reduce power and land ASAP

B. Low Oil Pressure

i. Possible Cause - Broken Pressure Relief Valve, Insufficient Oil, Burned Out Bearings
ii. Corrective Action - Land ASAP or feather the prop and stop engine

C. Checklist
i. Oil Temp: CHECK
ii. If Pressure drops below Green Arc but Temp is normal: LAND AT NEAREST FIELD
iii. If Pressure drops below Green Arc and Temp is rising: REDUCE THROTTLE TO MIN REQ POWER
a. Be prepared for engine failure and emergency landing

4. Fuel Starvation

A. Normally indicated by a rough running engine, and can be caused by blocked lines or empty tanks
B. Check the fuel flow gauge
C. Fuel Shutoff: OPEN
D. Mixture: FULL RICH
E. Electric Fuel Pump: ON
i. Check the fuel flow gauge again

5. Engine Overheat

A. The oil temperature gauge is the primary instrument in determining if the engine is overheating
B. Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

6. Hydraulic Malfunction (not applicable to DA20)

A. If the hydraulic pump were to fail, there are manual means to raise/lower the gear
i. Some airplanes will automatically lower the gear (DA42)

7. Electrical Malfunction

A. The generator/alternator is the cause of most electrical system failures (indicated on the ammeter)
i. Once the generator goes offline, the only electrical source remaining is the battery
a. The battery although may have very little time available

B. Electrically powered gear and flaps use up power at rates much greater than most other equipment
i. Selecting these motors on a partially depleted battery could result in immediate loss of power

C. Steps
i. Turn off all but the most necessary electrical equipment
a. Save as much power as possible
ii. Notify ATC immediately and request vectors for a landing at the nearest airport
iii. Expect to make a no flap landing, and anticipate a manual gear extension

D. Checklist
i. Total Electrical Failure
a. Battery Circuit Breaker: RESET, if tripped
b. GEN/BAT Master: check ON
c. Master Switch: OFF if power not restored
d. If unsuccessful, land at the nearest suitable airport

ii. Generator Failure (GEN. Annunciator Light Illuminated)
a. GEN/BAT Master: Cycle Generator Master Switch OFF - ON
b. Generator Circuit Breaker: RESET, if tripped
c. Generator Control Breaker: RESET, if tripped
d. If GEN cannot be brought online: Switch off all non-flight essential electrical consumers

- Monitor the Ammeter and Voltmeter
- Land at the nearest airport

iii. Low Voltage Indication (Needle in yellow arc) While on the Ground

a. Engine RPM: Increase RPM until needle is in the Green Arc (Should occur before 1100 RPM)
b. Non-Flight Essential Electrical Consumers: Switch OFF consumers until in the Green Arc
c. If needle remains in the yellow arc, and the ammeter is indicating left of center (discharge), discontinue any flight activity
d. Low Voltage Indication (needle in yellow arc) While in the Air
   - Non-Flight Essential Electrical Consumers: OFF
   - If needle stays in the yellow arc, and the ammeter indicates a discharge, use GEN FAILURE

8. Induction Icing

A. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
   i. Ice can also form on the exterior of the airplane, and clog the air intake openings
B. Corrective Action
   i. Use the Alternate Air source
C. Icing Checklist
   i. Leave icing area (change altitude or flight direction to reach a higher temp)
   ii. Continue to move the control surfaces to maintain mobility
   iii. Alternate Air: ON
   iv. Increase RPM to avoid icing of prop blades
   v. Cabin Heat: ON DEFROST

9. Door or Window Opening in Flight

A. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following:
   i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
   ii. Do not rush to land the plane if the door opens during lift off
      a. Climb to normal pattern altitude, fly a normal pattern, make a normal landing
   iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
   iv. Most doors will not stay open, they will usually bang open then settle partially closed
      a. A slip toward the door may open it wider, and a slip away may push it closed

10. Inoperative or "Runaway" Trim

A. Checklist
   i. Control Stick: Grip stick and maintain control of the airplane
   ii. Trim Motor Circuit Breaker: PULL the breaker
   iii. Rocker Switch: Check if depressed
B. If the reason for the runaway trim is obvious and has been resolved, engage the breaker

11. Flap Malfunction

A. Total Flap Failure
   i. This will necessitate a no flap approach and landing
      a. This will require substantially more runway than normal (as much as 50% more)
      b. The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
         - This can make the runway difficult to see
      c. A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
      d. The airplane will tend to float considerably during roundout
   ii. If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle
B. Asymmetric (Split) Flap
   i. A situation in which one flap deploys/retracts while the other remains in position
   ii. The problem is indicated by a pronounced roll toward the wing with the least flap deflection

iii. Countering
   a. Countered with opposite aileron
   b. The yaw caused by the additional drag on the extended flap side will require opposite rudder
      - Aileron and opposite rudder results in a cross controlled situation
   c. Almost full aileron may be necessary at the reduced airspeed to maintain wings level
      - Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
         a The additional roll control to counteract the cross-wind may not be available
iv. Be aware of the differing stall speeds of each wing
   a. The wing with the retracted flap will stall much earlier - possible cross-controlled stall condition
v. Approach and landing should be flown at a higher than normal airspeed

12. Pressurization Malfunction

A. Descend or use supplemental oxygen
   i. Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Cessna 152

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

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Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. Smoke, Fire, or Both, During Ground or Flight Operations

A. In-Flight Smoke/Fire - In any fire, it is essential the source is discovered first
- Engine Fire in Flight
  - Usually caused by a failure allowing a combustible substance to contact a hot surface
  - Checklist

• Shut off the fuel supply to the engine a Mixture Control: Idle Cutoff b Fuel Shut-Off Valve: Off • Master Switch: Off	• Cabin Ht & Cabin Air: Off a Except wing root • Airspeed: 85 KIAS • Forced Landing: Execute

    - If fire is not extinguished at 85 KIAS, increase glide speed to find an airspeed which will provide an incombustible mixture
  - Perform an emergency landing
  - Keep in mind that
    - There may be severe structural damage and control could be lost at any time
    - The airplane may still be on fire and susceptible to explosion
    - The airplane is expendable and the only thing that matters is the safety of those onboard
- Electrical Fire in Flight
  - Indication is usually the distinct odor of burning insulation (acrid)
  - Checklist

• Master Switch: Off • All Other Switches (except ignition): Off • Vents/Cabin Air/Heat: Closed • Fire Extinguisher: Activate (if available) If fire appears out, and electrical power is necessary for continuance of flight: • Master Switch: On • Circuit Breakers: Check for faulty circuit, do not reset

- Radio/Electrical Switches: ON ne at a time, with delay after each until short circuit is localized
- Vents/Cabin Air/Heat: Open when it is ascertained that the fire is completely extinguished

- After discharging an extinguished in a closed cabin, ventilate the cabin
- If the fire returns when restoring power (i.e. the system that received power is a cause of the fire), immediately turn off the switch/system and fight the fire

- Wing Fire
  - The POH does not specify whether this checklist applies inflight or on the ground
  - Basically, remove all power sources from the wing
  - Checklist
    - Navigation Lights – Off
    - Strobe Lights: Off
    - Pitot Heat: Off
  - Perform a sideslip to keep the flames away from the fuel tank and cabin, and land as soon as possible, with flaps retracted
- Cabin Fire
  - POH does not specify whether this checklist applies inflight or on the ground
  - Usually result from:
    - Careless smoking on the part of the pilot and/or passengers
    - Electrical system malfunctions
    - Heating system malfunctions
  - Two immediate demands:
    - Attacking the fire
    - Getting the airplane safely on the ground as quickly as possible
  - Checklist
    - Master Switch: Off
    - Vents/Cabin Air/Heat: Closed (to avoid drafts)
    - Fire Extinguisher: Activate (if available)
      a. After discharging a fire extinguisher in a closed cabin, ventilate the cabin
    - Land as soon as possible (on the ground the best course of action is likely to evacuate)

B. Ground Smoke/Fire

- During Start on Ground
  - Checklist
    - Cranking: Continue
      a. To get a start which would pull the fuel and flames into the engine

    If Engine Starts
    - Power: 1700 RPM (for a few minutes)
    - Engine: Shutdown (check for damage)

    If Engine Fails to Start
    - Cranking: Continue, in an attempt to obtain a start
    - Engine: Secure
      a. Master Switch: Off
      b. Ignition Switch: Off
      c. Fuel Shutoff Valve: Off
    - Fire Extinguisher: Obtain
      a. Have ground attendants obtain if not installed
    - Fire: Extinguish using fire extinguisher, wool blanket, or dirt

- Fire Damage: Inspect

2. Rough Running Engine or Partial Power Loss

A. No specific rough running engine checklist, but in the Amplified Emergency Procedures section the POH references Rough Engine Operation or Loss of Power

- Carburetor Icing
  - A gradual loss of RPM and eventual engine roughness may result from the formation of carburetor ice
  - To clear the ice:
    - Apply full throttle
    - Pull the carb heat knob full out until the engine runs smoothly
    - Remove the carb heat and readjust the throttle
  - If conditions require continued use of carb heat in flight, use the minimum amount of heat necessary to prevent ice from forming and lean the mixture slightly for smoothest engine operation
- Spark Plug Fouling
  - Slight engine roughness can be caused by spark plug fouling (carbon or lead deposit on the spark plug)
    - Verify by turning the mags switch momentarily from Both to either L or R. An obvious power loss in single mag operation is evidence of spark plug or magneto trouble
  - Procedure (assuming spark plugs are the issue. Magento malfunction is described below)
    - Lean the mixture to the recommended lean setting for cruise flight
    - If the problem does not clear up in several minutes, determine if a richer mixture setting will produce smoother operation. If not, proceed to the nearest airport for repairs using the Both position of the mags switch unless extreme roughness makes a single mag position necessary
- Magneto Malfunction
  - Sudden engine roughness or misfiring is usually a sign of a magneto problem
    - Changing the mags from Both to L and R positions will identify the malfunctioning magneto
  - Procedure
    - Select different power settings and enrichen the mixture to determine if continued operation on Both mags is practicable. If not, change to the good mag and continue to the nearest airport for repairs
- Forced Landing - Precautionary Landing with Engine Power Checklist
    - Airspeed: 60 KIAS
    - Wing Flaps: 20°
    - Selected Field: Fly over, noting terrain and obstructions, then retract flaps upon reaching a safe altitude and airspeed
    - Radio and Electrical Switches: Off
    - Wing Flaps: 30° on final approach
    - Airspeed: 55 KIAS
    - Master Switch: Off
    - Doors: Unlatch prior to touchdown
    - Touchdown: Slightly tail low
    - Ignition Switch: Off
    - Brakes: Apply heavily
- As mentioned in the checklist above, before attempting an off airport landing with engine power available, one should fly over the landing area at a safe but low altitude to inspect the terrain for obstructions and surface conditions

3. Loss of Engine Oil Pressure

A. High Oil Pressure

- Possible Cause - Cold oil or possible internal plugging
- Corrective Action - If cold, allow the engine to warm, if not, reduce power and land ASAP

B. Low Oil Pressure
- Possible Cause - Broken Pressure Relief Valve, Insufficient Oil, Burned Out Bearings
- Corrective Action - Land ASAP, anticipate engine failure, follow the forced landing procedures in the POH (shown above)

C. POH Amplified Emergency Procedures – Low Oil Pressure
- If low oil pressure is accompanied by normal oil temperature, there is a possibility the oil pressure gauge or relief valve is malfunctioning
    - A leak in the line is not necessarily cause for an immediate precautionary landing because an orifice in this line will prevent a sudden loss of oil from the engine sump
        - However, a landing at the nearest suitable airport would be advisable to inspect the source of the trouble
- If a total loss of oil pressure is accompanied by a rise in oil, there is good reason to suspect an engine failure is imminent – reduce power immediately and select a field suitable for a forced landing. Use only the minimum power necessary to reach the landing site

4. Fuel Starvation

A. Normally indicated by a rough running engine or engine failure, and can be caused by blocked lines or empty tanks

B. The POH does not have a specific fuel starvation checklist
- Check the fuel gauges to determine if fuel starvation is in fact the problem. IF the engine cannot be restarted (as described below), execute the Forced Landing checklist

C. Engine Failure During Flight:
- Airspeed: 60 KIAS
- Carburetor Heat: On
- Primer: In and locked
- Fuel Shutoff Valve: On
- Mixture: Rich
- Ignition Switch: Both (or Start if propeller is stopped)

- Continue with Emergency Landing without Engine Power Checklist

5. Engine Overheat

A. There is no specific engine overheat checklist in the POH, but the following is applicable

B. The oil temperature gauge is the primary instrument in determining if the engine is overheating
- If a total loss of oil pressure and a rise in oil temperature occur at about the same time, it could mean the engine is about to fail. Reduce power immediately and select a field suitable for a forced landing. Use only the minimum power necessary to reach the landing site
- Execute the Emergency Landing without Engine Power, or Precautionary Landing with Engine Power if required

C. Although the POH does not have a specific, engine overheat checklist, the following can serve as guidelines:
- Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce pwr
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

6. **Hydraulic Malfunction**
   A. Brake failure
      - Symptoms of impending brake failure:
         - Gradual decrease in braking action after brake application
         - Noisy or dragging brakes
         - Soft or spongy pedals
         - Excessive brake travel
         - Weak braking action
      - If during taxi or landing roll, braking action decreases let up on the pedals and the reapply the brakes with heavy pressure
      - If the brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure
      - If one brake becomes weak or fails, use the other brake sparingly while using opposite rudder, as required, to offset the good brake
      - *Not in the POH* If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking
7. **Electrical Malfunction**
   A. General
      - The generator/alternator is the cause of most electrical system failures
         - Once the generator goes offline, the only electrical source remaining is the battery
            - The battery although may have very little time available
      - Electrically powered gear and flaps use up power at rates much greater than most other equipment
         - Selecting these motors on a partially depleted battery could result in immediate loss of power
      - Malfunctions in the electrical system can be detected through regular monitoring of the ammeter and low-voltage warning light
         - The cause of these malfunctions is usually difficult to determine
            - A broken alternator drive belt or wiring is the most likely cause of alternator failures
            - A damaged or improperly adjusted alternator control unit can also cause malfunctions
   B. Electrical power malfunctions generally fall into two categories:
      - Excessive Rate of Charge
         - After 30 minutes of cruise flight, the main battery ammeter should be indicating less than 2 needle widths of charging current. If the charging current remains above this value on a long flight, the battery electrolyte could overheat and evaporate
            - Electronic components can be adversely affected by higher than normal voltage
            - The Alternator Control Unit should disconnect the alternator if the charge increases to more than 31.5 volts
               a If the ACU does not operate correctly, the alternator should be turned off, alternator circuit breaker pulled, nonessential electrical equipment turned off, and the flight terminated as soon as practical
      - Insufficient Rate of Charge
         - i.e. the alternator is not providing the necessary charge
            - If the over-voltage sensor shuts down the alternator, or the alternator circuit breaker trips a discharge will be show on the ammeter followed by the low-voltage warning light
            - This may be a nuisance trip, attempt to energize the alternator system by:
               a Turning off the radios
               b Checking the alternator circuit breaker is in
               c Turning the master switch off and back on
               d If this doesn't reset the system, there is an alternator system problem

1. The flight should be terminated and the current drain on the battery minimized to extend the amount of time on battery power
2. If the emergency occurs at night, power must be conserved for later use of the landing light and flaps

C. General Steps to any electrical malfunction
- Turn off all but the most necessary electrical equipment
  - Save as much power as possible
- Notify ATC immediately and request vectors for a landing at the nearest airport
- Expect to make a no flap landing, and anticipate a manual gear extension

D. Checklists
- Ammeter Shows Excessive Rate of Discharge:
  - Alternator: Off
  - Alternator Circuit Breaker: Pull
  - Nonessential Electrical Equipment: Off
  - Flight: Terminate as soon as practical
- Low Voltage Light Illuminates During Flight:
  - Radios: Off
  - Alternator Circuit Breaker: Check In
  - Master Switch: Off (both sides)
  - Master Switch: On
  - Low-Voltage Light: Check Off
  - Radios: On

  If low-voltage light illuminates again:
  - Alternator: Off
  - Nonessential Radio and Electrical Equipment: Off
  - Flight: Terminate as soon as practical

    Note:

    a Illumination of the low-voltage light may occur during low RPM conditions. Under these conditions, the light will go out at higher RPM. The Master Switch does not need to be recycled since an overvoltage has not occurred

8. Induction Icing

A. General
- Flight into icing conditions is prohibited and extremely dangerous
  - The best action is to turn back or change altitude to escape the icing conditions

B. See Carburetor Icing Checklist in Section 2.A., above

C. Inadvertent Icing Encounter Checklist:
- Pitot Heat: On
- Turn back or change altitude to get out of icing conditions
- Cabin Heat: Pull full out for maximum defrost air temperature
- Cabin Air: For greater airflow at reduced temperatures, adjust the cabin air as required
- Throttle: Open to increase engine speed and minimize ice buildup on the propeller blades
- Watch for signs of carburetor air filter ice and apply carb heat as required
  - An unexpected loss of engine speed could be caused by carburetor ice or air intake filter ice
  - Lean the mixture for maximum RPM if carburetor heat is used continuously
- Plan a landing at the nearest airport
  - With extremely rapid ice build-up, select a suitable off airport landing site

- With ice accumulation of 0.25” or more on the wing leading edge, be prepared for significantly higher stall speed
- Leave wing flaps retracted
    - With severe ice build-up on the horizontal tail, the change in wing wake airflow direction caused by flap extension could result in a loss of elevator effectiveness
- Open the left window, and, if practical, scrape ice from a portion of the windshield for visibility
- Perform a landing approach using a forward slip, if necessary, for improved visibility
- Approach at 65 to 75 KIAS depending on the amount of ice accumulation
- Perform the landing in a level attitude

9. Door or Window Opening in Flight

A. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following:
- Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
- Do not rush to land the plane if the door opens during lift off
    - Climb to normal pattern altitude, fly a normal pattern, make a normal landing
- Don’t release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
- Most doors will not stay open, they will usually bang open then settle partially closed
    - A slip toward the door may open it wider, and a slip away may push it closed

10. Inoperative or “Runaway” Trim

A. If installed, follow the manufacturer’s checklist

11. Flap Malfunction

A. Total Flap Failure - this is a general recommendation and not from the Cessna 152 POH
- This will necessitate a no flap approach and landing
    - This will require substantially more runway than normal (as much as 50% more depending on the aircraft – reference the POH performance)
    - The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
        - This can make the runway difficult to see
    - A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
    - The airplane will tend to float considerably during roundout
- If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle

B. Asymmetric (Split) Flap- this is a general recommendation and not from the Cessna 152 POH
- A situation in which one flap deploys/retracts while the other remains in position
- The problem is indicated by a pronounced roll toward the wing with the least flap deflection
- Countering
    - Countered with opposite aileron
    - The yaw caused by the additional drag on the extended flap side will require opposite rudder
        - Aileron and opposite rudder results in a crossed control situation
    - Almost full aileron may be necessary at the reduced airspeed to maintain wings level
        - Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
            a The additional roll control to counteract the cross-wind may not be available
- Be aware of the differing stall speeds of each wing
    - The wing with the retracted flap will stall much earlier - possible crossed control stall condition
- Approach and landing should be flown at a higher than normal airspeed

12. Pressurization Malfunction

A. Descend or use supplemental oxygen
- Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Cessna 172S G1000

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Smoke, Fire, or both, during Ground or Flight Operations 2. Rough Running Engine or Partial Power Loss 3. Loss of Engine Oil Pressure 4. Fuel Starvation 5. Engine Overheat 6. Hydraulic Malfunction 7. Electrical Malfunction 8. Induction Icing 9. Door or Window Opening in Flight 10. Inoperative or "Runaway" Trim 11. Flap malfunction 12. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the aircraft to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. Smoke, Fire, or Both, During Ground or Flight Operations

A. In-Flight Smoke/Fire - In any fire, it is essential the source is discovered first
- Engine Fire in Flight
  - Usually caused by a failure allowing a combustible substance to contact a hot surface
  - Checklist

• Shut off the fuel supply to the engine a Mixture Control: Idle Cutoff b Fuel Shut-Off Valve: Off c Fuel Pump: Off • Master Switch: Off	• Cabin Ht & Cabin Air: Off a Except overhead vents • Airspeed: 100 KIAS a See note below • Forced Landing: Execute

Note: If fire is not extinguished at 100 knots, increase glide speed to find an airspeed within limitations which will provide an incombustible mixture

  - Perform an emergency landing
  - Keep in mind that:
    - There may be severe structural damage and control could be lost at any time
    - The airplane may still be on fire and susceptible to explosion
    - The airplane is expendable and the only thing that matters is the safety of those onboard
- Electrical Fire in Flight
  - Indication is usually the distinct odor of burning insulation
  - Checklist:

• STBY BATT Switch: Off • Master Switch (Alt & BAT): Off • Cabin Vents: Closed (to avoid drafts) • Cabin Ht & Cabin Air: Off (Push full in. To avoid drafts.) • Fire Extinguisher: Activate (if available) • Avionics Switch (Bus 1 & Bus 2): Off

- All Other Switches (except Magnetos): Off

If the fire is extinguished and electric power is necessary to continue the flight to the nearest suitable airport or landing area:

- Circuit Breakers: Check
- Master Switch (ALT and BATT): On
- Stby Batt Switch – Arm
- Avionics Switch (Bus 1): On
- Avionics Switch (Bus 2): On

- If the fire returns when restoring power (i.e. the system that received power is a cause of the fire), immediately turn off the switch/system and fight the fire

- Wing Fire
  - The POH does not specify whether this checklist applies inflight or on the ground
  - Basically, remove all power sources from the wing
  - Checklist:
    - Land and Taxi Light Switches: Off
    - Nav Light Switch: Off
    - Strobe Light Switch: Off
    - Pitot Heat Switch: Off

  Note: Perform a sideslip to keep the flames away from the fuel tank and cabin. Land as soon as possible using flaps only as required for final approach and touchdown
- Cabin Fire
  - POH does not specify whether this checklist applies inflight or on the ground
  - Usually result from:
    - Careless smoking on the part of the pilot and/or passengers
    - Electrical system malfunctions
    - Heating system malfunctions
  - Two immediate demands:
    - Attacking the fire
    - Getting the airplane safely on the ground as quickly as possible
  - Checklist
    - Stby Batt Switch: Off
    - Master Switch (Alt and Bat): Off
    - Cabin Vents: Close
    - Cabin Ht and Cabin Air: Off
    - Fire Extinguished: Activate
      a. Ensure the fire is out before exterior air is used to remove smoke in the cabin
    - Cabin Vents: Open (when sure the fire is completely extinguished)
    - Cabin Ht and Cabin Air: On (when sure the fire is completely extinguished)
    - Land ASAP

B. Ground Smoke/Fire

- During Start on Ground
  - Checklist
    - Magnetos: Start (continue cranking)

    If Engine Starts
    - Power: 1800 RPM (for a few minutes)
    - Engine: Shutdown (check for damage)

    If Engine Fails to Start
    - Magnetos: Off
    - Stby Batt Switch: Off
    - Master Switch (Alt & Batt): Off
    - Engine: Secure
    - Parking Brake: Release

• Throttle: Full • Mixture: Idle Cutoff • Magnetos: Start (continue cranking) • Fuel Shutoff Valve: Off • Fuel Pump: Off	• Fire Extinguisher: Obtain • Airplane: Evacuate • Fire: Extinguish • Fire Damage: Inspect

2. Rough Running Engine or Partial Power Loss

A. No specific rough running engine checklist, but in the Amplified Emergency Procedures section the POH references Rough Engine Operation or Loss of Power:

- Spark Plug Fouling
  - Slight engine roughness can be caused by spark plug fouling (carbon or lead deposit on the spark plug)
    - Verify by turning the mags switch momentarily from Both to either L or R. An obvious power loss in single mag operation is evidence of spark plug or magneto trouble
  - Procedure
    - Lean the mixture to the recommended lean setting for cruise flight
    - If the problem does not clear up in several minutes, determine if a richer mixture setting will produce smoother operation. If not, proceed to the nearest airport for repairs using the Both position of the mags switch unless extreme roughness makes a single mag position necessary
- Magneto Malfunction
  - Sudden engine roughness or misfiring is usually a sign of a magneto problem
    - Changing the mags from Both to L and R positions will identify the malfunctioning magneto
  - Procedure
    - Select different power settings and enrichen the mixture to determine if continued operation on Both mags is possible. If not, change to the good mag and continue to the nearest airport for repairs
- Idle Power Engine Roughness
  - An excessively rich idle fuel flow may cause low speed engine roughness during flight
  - During most in-flight low engine speeds (power off stalls, approach to landing, etc.), the mixture control is normally in the full-rich position. However, to improve engine roughness (caused by an improperly adjusted fuel servo) during low engine speeds while in flight, you should lean the mixture.
    - You may also have to lean the fuel mixture if this low engine speed results in power loss and you need to restart the engine during flight.
  - In all cases, you should land the airplane at the nearest airport for repairs if low speed engine roughness requires you to adjust the fuel mixture control to improve engine operation.
- Engine Driven Fuel Pump Failure
  - Failure of the engine driven fuel pump will be shown by a sudden reduction in the fuel flow indication immediately before a loss of power while operating from a fuel tank containing adequate fuel
  - Procedure
    - Immediately set the Fuel Pump switch to On to restore engine power
    - The flight should be terminated as soon as practical
- Excessive Fuel Vapor
  - Fuel vapor in the fuel injection system is most likely to occur on the ground, typically during prolonged taxi operations when operating at higher altitudes and/or in unusually warm temperatures
    - Excessive fuel vapor accumulation is shown by fuel flow indicator fluctuations greater than 1 gal per hour
      - a This condition, with leaner mixtures or with larger fluctuations, can result in power surges, and if not corrected, may cause power loss
  - Procedure

    - To slow vapor formation and stabilize fuel flow on the ground or in the air, set the Fuel Pump switch to On and adjust the mixture for smooth engine operation
    - If vapor symptoms continue, select the opposite fuel tank
    - When fuel flow stabilizes, set the Fuel Pump to Off and adjust the mixture as desired
- Forced Landing - Precautionary Landing with Engine Power Checklist:
    - Pilot and Passenger Seat Backs: Most upright position
    - Seats and Seat Belts: Secure
    - Airspeed: 65 KIAS
    - Wing Flaps: 20°
    - Selected Field: Fly over (noting terrain and obstructions)
    - Wing Flaps: Full (on final app)
    - Airspeed: 65 KIAS
    - Stby Batt Switch: Off
    - Master Switch (Alt & Batt): Off (when landing assured)
    - Doors: Unlatch prior to touchdown
    - Touchdown: Slightly tail low
    - Mixture Control: Idle Cutoff
    - Magnetos Switch: Off
    - Brakes: Apply heavily

3. Loss of Engine Oil Pressure

A. High Oil Pressure
- Possible Cause - Cold oil or possible internal plugging
- Corrective Action - If cold, allow the engine to warm, if not, reduce power and land ASAP

B. Low Oil Pressure
- Possible Cause - Broken Pressure Relief Valve, Insufficient Oil, Burned Out Bearings
- Corrective Action - Land ASAP, anticipate engine failure, follow the forced landing procedures in the POH (shown above)

C. POH Amplified Emergency Procedures – Low Oil Pressure
- If the low oil pressure annunciator (Oil Press) comes on, check the oil pressure indicator (Oil Pres on Engine page or Oil PSI on System Page) to confirm the low oil pressure condition
    - If oil pressure and temperature remain normal, it is possible that the oil pressure sending unit or relief valve is malfunctioning – land at the nearest airport to determine the source of the problem
- If a total loss of oil pressure and a rise in oil temperature occur at about the same time, it could mean that the engine is about to fail – reduce power immediately and select a field suitable for a forced landing. Use only the minimum power necessary to reach the landing site

4. Fuel Starvation

A. Normally indicated by a rough running engine or engine failure, and can be caused by blocked lines or empty tanks

B. The POH does not have a specific fuel starvation checklist
- Check the fuel gauges to determine if fuel starvation is in fact the problem. IF the engine cannot be restarted (as described below), execute the Forced Landing checklist

C. Engine Failure During Flight:
- Airspeed: 68 KIAS
- Fuel Shutoff: On
- Fuel Selector: Both
- Fuel Pump: ON

- Mixture: Rich (if restart has not occurred)
- Magnetos: Both (or start if propeller is stopped)
  - If prop is windmilling, engine will restart automatically within a few seconds. If prop has stopped, turn mags switch to start, advance throttle slowly from idle and lean the mixture from full rich as required to obtain smooth operation

5. Engine Overheat

A. There is no specific engine overheat checklist in the POH, but the following is applicable

B. The oil temperature gauge is the primary instrument in determining if the engine is overheating

- If a total loss of oil pressure and a rise in oil temperature occur at about the same time, it could mean the engine is about to fail. Reduce power immediately and select a field suitable for a forced landing. Use only the minimum power necessary to reach the landing site
- Execute the Emergency Landing without Engine Power, or Precautionary Landing with Engine Power if required

C. Although the POH does not have a specific, engine overheat checklist, the following can serve as guidelines:

- Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce pwr
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

6. Hydraulic Malfunction

A. Brake failure

- Symptoms of impending brake failure:
  - Gradual decrease in braking action after brake application
  - Noisy or dragging brakes
  - Soft or spongy pedals
  - Excessive brake travel
  - Weak braking action
- If during taxi or landing roll, braking action decreases let up on the pedals and the reapply the brakes with heavy pressure
- If the brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure
- If one brake becomes weak or fails, use the other brake sparingly while using opposite rudder, as required, to offset the good brake
- *Not in the POH* If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking

7. Electrical Malfunction

A. General

- The generator/alternator is the cause of most electrical system failures
  - Once the generator goes offline, the only electrical source remaining is the battery
    - The battery although may have very little time available
- Electrically powered gear and flaps use up power at rates much greater than most other equipment
  - Selecting these motors on a partially depleted battery could result in immediate loss of power
- Malfunctions in the electrical system can be detected through regular monitoring of the main battery ammeter (M Batt Amps) and the main electric bus voltmeter (M Bus Volts)

- Electrical power malfunctions generally fall into two categories:
  - Excessive Rate of Charge
    - After 30 minutes of flight, the main battery ammeter should be indicating less than 5 amps. If the charging current remains above this value on a long flight, the battery electrolyte could overheat and evaporate
      a. Electronic components can be adversely affected by higher than normal voltage
      b. The Alternator Control Unit should disconnect the alternator if the charge increases to more than 31.75 volts
         1. If the ACU does not operate correctly, the Master Switch (Alt only) should be turned Off
  - Insufficient Rate of Charge
    - i.e. the alternator is not providing the necessary charge
      a. The ACU can de-energize the alternator due to a minor disturbance in the electrical system, resulting in a nuisance opening of the Alt Field circuit breaker
      b. Attempt to energize the alternator system by turning the Master Switch (Alt) Off, check the Alt Field circuit breaker is in and then turning the Master Switch (Alt) back on
         1. If this doesn't reset the system, there is an alternator system problem (more below)

B. General Steps to any electrical malfunction
- Turn off all but the most necessary electrical equipment
  - Save as much power as possible
- Notify ATC immediately and request vectors for a landing at the nearest airport
- Expect to make a no flap landing, and anticipate a manual gear extension

C. Checklists
- High Volts Annunciator or M Batt Amps More than 40:
  - Master Switch (Alt): Off
  - Electrical Load – Reduce Immediately. All Off:
    - Avionics Switch (Bus 1)
    - Pitot Heat
    - Beacon Light
    - Land Light
    - Taxi Light
    - Nav Light
    - Strobe Light
    - Cabin Pwr 12V

      Note: The main battery supplies electrical power to the main and essential buses until M Bus Volts decreases below 20 volts at which point the standby battery system will automatically supply power to the essential bus for at least 30 minutes

      Note: Select Com 1 Mic and Nav 1 on the audio panel and tune to the active frequency before setting Avionics Bus 2 to Off. If Com 2 Mic and Nav 2 are selected when Avionics Bus 2 is set to Off, the Com and Nav radios cannot be tuned
  - Com 1 and Nav 1: Tune to active frequency
  - Com 1 Mic and Nav 1: Select
    - Com 2 Mic and Nav 2 will be inoperative once Avionics Bus 2 is selected Off
  - Avionics Switch (Bus 2): Off (keep on if in clouds)

Note: With Avionics Bus 2 Off, the following will be inoperative

a. Autopilot
b. Comm 2
c. Transponder
d. Audio Panel
e. Nav 2
f. MFD

- Land as soon as practical

Note: Make sure a successful landing is possible before extending the flaps. The flap motor is a large electrical load during operation

- Low Volts Annunciator Below 1000 RPM:
    - Throttle: 1000 RPM
    - Low Volts Annunciator: Check Off
        - If it remains On, authorized maintenance personnel must do an electrical system inspection prior to the next flight
- Low Volts Annunciator (does not go off at higher RPMs):
    - Master Switch (Alt only): Off
    - Alt Field Circuit Breaker: Check in
    - Master Switch (Alt and Bat): On
    - Low Volts Annunciator: Check off
    - M Bus Volts: Check 27.5 V minimum
    - M Batt Amps: Check charging (+)

If Low Volts Annunciator remains On

- Master Switch (Alt only): Off
- Electrical Load – Reduce Immediately. All Off:
    - Avionics Switch (Bus 1)
    - Pitot Heat
    - Beacon Light
    - Land Light
    - Taxi Light
    - Nav Light
    - Strobe Light
    - Cabin Pwr 12V

      Note: The main battery supplies electrical power to the main and essential buses until M Bus Volts decreases below 20 volts at which point the standby battery system will automatically supply power to the essential bus for at least 30 minutes

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- Comm 1 and Nav 1: Tune to active frequency
- Com 1 Mic and Nav 1: Select
    - Com 2 mic and Nav 2 will be inoperative once Avionics Bus 2 is selected to Off)
- Avionics Switch (Bus 2): Off (keep on if in clouds)

Note: With Avionics Bus 2 Off, the following will be inoperative

a Autopilot
b Comm 2
c Transponder
d Audio Panel
e Nav 2
f MFD

- Land as soon as practical

Note: Make sure a successful landing is possible before extending the flaps. The flap motor is a large electrical load during operation

8. Induction Icing

A. POH Amplified Emergency Procedures
- Flight into icing conditions is prohibited and extremely dangerous
  - The best action is to turn back or change altitude to escape the icing conditions

B. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine. In extremely rare instances, ice can completely block the fuel injection air reference tubes
- Ice can also form on the exterior of the airplane, and clog the air intake openings
- In all situations mentioned, the throttle should be positioned for maximum RPM (in some instances, the throttle may need to be retarded to obtain maximum RPM). The mixture should then be adjusted for maximum RPM

C. Corrective Action
- Use the Alternate Air source

D. Icing Checklist

- Pitot Heat: On
- Turn back or change altitude to get out of icing conditions
- Cabin Ht: On
- Defroster Outlets: Open (max windshield defrost)
- Cabin Air: Adjust (max defroster heat and airflow) – Checklist continued below
- Watch for signs of induction air filter icing:
  - A loss of engine RPM can be caused by ice blocking the air intake filter
  - Adjust throttle to hold engine RPM
  - Adjust mixture for changes in power
- Plan a landing at the nearest airport
  - With extremely rapid ice build-up, select a suitable off airport landing site
- With ice accumulation of 0.25” or more on the wing leading edge, be prepared for significantly higher power requirements, higher approach and stall speeds and a longer landing roll
- Leave wing flaps retracted
  - With severe ice build-up on the horizontal tail, the change in wing wake airflow direction caused by flap extension could result in a loss of elevator effectiveness
- Open the left window, and, if practical, scrape ice from a portion of the windshield for visibility
- Perform a landing approach using a forward slip, if necessary, for improved visibility
- Approach at 65 to 75 KIAS depending on the amount of ice accumulation

- Perform the landing in a level attitude
- Missed approaches should be avoided whenever possible because of severely reduced climb capability

9. Door or Window Opening in Flight

A. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following:
- Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
- Do not rush to land the plane if the door opens during lift off
  - Climb to normal pattern altitude, fly a normal pattern, make a normal landing
- Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
- Most doors will not stay open, they will usually bang open then settle partially closed
  - A slip toward the door may open it wider, and a slip away may push it closed

10. Inoperative or "Runaway" Trim

A. Checklist

- Control Wheel: Grasp firmly (regain control)
- A/P Trim Disc Button: Press and Hold (throughout recovery)
- Elevator Trim Control: Adjust manually (as necessary)
- Auto Pilot Circuit Breaker: Open
- A/P Trim Disc Button: Release

B. Do not engage the autopilot until the cause of the malfunction has been corrected

11. Flap Malfunction

A. Total Flap Failure
- This will necessitate a no flap approach and landing
  - This will require substantially more runway than normal (as much as 50% more depending on the aircraft – reference the POH performance)
  - The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
    - This can make the runway difficult to see
  - A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
  - The airplane will tend to float considerably during roundout
- If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle
  - This is a general recommendation and not from the Cessna 172 POH

B. Asymmetric (Split) Flap
- A situation in which one flap deploys/retracts while the other remains in position
- The problem is indicated by a pronounced roll toward the wing with the least flap deflection
- Countering
  - Countered with opposite aileron
  - The yaw caused by the additional drag on the extended flap side will require opposite rudder
    - Aileron and opposite rudder results in a crossed control situation
  - Almost full aileron may be necessary at the reduced airspeed to maintain wings level
    - Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
      - a The additional roll control to counteract the cross-wind may not be available
- Be aware of the differing stall speeds of each wing
  - The wing with the retracted flap will stall much earlier - possible crossed control stall condition
- Approach and landing should be flown at a higher than normal airspeed

12. Pressurization Malfunction

A. Descend or use supplemental oxygen
- Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Cirrus SR20

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. General Info 2. Smoke, Fire, or both, during Ground or Flight Operations 3. Rough Running Engine or Partial Power Loss 4. Loss of Engine Oil Pressure 5. Fuel Starvation 6. Engine Overheat 7. Hydraulic Malfunction 8. Electrical Malfunction 9. Induction Icing 10. Door or Window Opening in Flight 11. Inoperative or "Runaway" Trim 12. Flap Malfunction 13. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. **General Info**
   - A. Review Emergency / Abnormal Procedure Overview
     - i. Section 3 Emergency Procedures
       - a. Introduction
       - b. Airspeeds for Emergency Operations
       - c. Emergency Procedures Guidance
       - d. Perspective +: Review entire Introduction
     - ii. Section 3A Abnormal Procedures
       - a. Introduction
       - b. Abnormal Procedures Guidance
       - c. Perspective +: Review entire Introduction
   - B. Highlights:
     - i. Methodology (MATL)
       - a. Maintain Aircraft Control
       - b. Analyze the Situation
       - c. Take Appropriate Action
       - d. Land as Soon as Conditions Permit
     - ii. Memory Items
       - a. Checklist steps emphasized by underlining
       - b. Should be memorized for accomplishment without reference to the procedure
     - iii. Land as Soon as Practicable vs Possible
       - a. Practicable: Extended flight is not recommended and the pilot should proceed to land
         - Not necessarily at the first or closest landing location
         - Pilot should use discretion and consider all factors
       - b. Possible: Land without delay at the first site a safe landing can be made
2. **Smoke, Fire, or Both, During Ground or Flight Operations**
   - A. Ground Smoke/Fire

- i. Engine Fire During Start – Reference checklist in Section 3 of the POH
  - a. May be caused by fuel igniting in the fuel induction systems. Attempt to draw the fire back into the engine by continuing to crank the engine
  - b. If flames persist, perform Emergency Engine Shutdown on Ground & Emergency Ground Egress
- ii. Emergency Engine Shutdown on Ground – Reference checklist in Section 3 of the POH
- iii. Emergency Ground Egress checklists – Reference checklist in Section 3 of the POH

B. In-Flight Smoke/Fire

- i. General
  - a. In any fire, it is essential the source is discovered first
  - b. Prepare to land without delay while completing the fire and /or smoke procedures
  - c. If it cannot be verified that the fire is completely extinguished, land immediately at the nearest suitable airfield or landing site
  - d. Keep in mind that with a fire:
    - There may be severe structural damage and control could be lost at any time
    - The airplane may still be on fire and susceptible to explosion
    - The airplane is expendable and the only thing that matters is the safety of those onboard
- ii. Engine Fire in Flight – Reference checklist in Section 3 of the POH
  - a. Often caused by a failure allowing a combustible substance to contact a hot surface
- iii. Wing Fire in Flight – Reference checklist in Section 3 of the POH
- iv. Cabin Fire in Flight – Reference checklist in Section 3 of the POH
  - a. May result from:
    - Careless smoking on the part of the pilot and/or passengers
    - Electrical system malfunctions
    - Heating system malfunctions
  - b. Two immediate demands:
    - Attack the fire
    - Get the airplane safely on the ground as quickly as possible
  - c. Indication of an electrical fire is usually the distinct odor of burning insulation (acrid smell)

3. Rough Running Engine or Partial Power Loss

A. Engine Partial Power Loss – Reference checklist in Section 3 of the POH

B. Indications

- i. Fluctuating RPM, reduced or fluctuating MP, low oil pressure, high oil temp, rough engine sound
  - a. Mild engine roughness may be caused by fouled spark plug(s)
  - b. Sudden engine roughness or misfiring is usually a magneto malfunction

C. Notes

- i. Low oil pressure may be indicative of imminent engine failure refer to Low Oil Pressure checklist
- ii. A damaged prop may cause extremely rough operation
  - a. Immediately shut down the engine and perform the Forced Landing checklist
- iii. If a fuel leak is responsible for the power loss, air cooling may prevent a fire
  - a. As power is reduced and the aircraft slowed, cooling may not be sufficient to prevent a fire
- iv. BOOST may clear the problem if there is vapor in the lines or the fuel pump has partially failed
  - a. The electric pump will not provide sufficient pressure if the engine driven pump fails entirely
- v. Selecting the other fuel tank may fix the problem if fuel starvation or contamination is the issue
- vi. Cycling the ignition may help identify a magneto or spark plug problem
- vii. Intake icing may lead to engine roughness – Opening the alternate air may fix the problem

D. General Plan

- i. If you can safely maintain level flight, land at a suitable airfield as soon as conditions permit

    ii. If you can't safely maintain level flight, use partial power to set up a forced landing
    iii. Always be prepared for a complete engine failure
        a. Consider CAPS deployment

4. Loss of Engine Oil Pressure

- A. Low Oil Pressure – Reference checklist in Section 3 of the POH
    - i. Depending on the SR20 model, checklist titles include:
        - a. Low Oil Pressure
        - b. Oil Pressure Out of Range
        - c. Oil Temperature High
- B. Overview
    - i. If low oil pressure is accompanied by rising oil temperature, the engine has likely lost a significant amount of oil and failure may be imminent
        - a. Immediately reduce power to idle and select a suitable forced landing field
    - ii. Prolonged use of high power will lead to engine damage and total failure
    - iii. Full power should only be used when
        - a. Operating close to the ground and only for the time needed to climb to a safe altitude
    - iv. If low oil pressure is accompanied by normal oil temperature, the pressure sensor, gage, or relief valve could be the problem
        - a. Land as soon as practical and determine the cause

5. Fuel Starvation

- A. Normally indicated by a rough running engine, and can be caused by blocked lines or empty tanks
    - i. Likely course of action is to initially run the Engine Partial Power Loss checklist
    - ii. In the case of fuel starvation, run the Engine Failure in Flight checklist
        - a. Leads to the Engine Airstart checklist
- B. POH Checklists
    - i. G1/G2
        - a. Engine Failure in Flight
        - b. Engine Airstart
    - ii. Perspective / Perspective +
        - a. Low Fuel Quantity
        - b. Fuel Imbalance
        - c. Engine Failure in Flight
        - d. Engine Airstart
    - iii. Section 3A Abnormal Procedures
        - a. Perspective
            - Low Fuel Quantity, Left/Right Fuel Tank Quantity, Fuel Filter in Bypass Mode, Fuel Imbalance
        - b. Perspective +
            - Fuel Low Total Caution, Fuel Imbalance Caution & Advisory

6. Engine Overheat

- A. The oil temperature gauge is the primary instrument in determining if the engine is overheating
- B. Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

- C. POH Checklist References
  - i. G1 / G2: Low Oil Pressure (generally accompanied by a high oil temperature)
    - a. Engine Partial Power Loss
    - b. No specific high oil temperature checklist
  - ii. Perspective: Oil Temperature High
    - a. High Cylinder Head Temperature checklist – worth mentioning/reviewing
  - iii. Perspective +: Oil Temp Warning
    - a. High Cylinder Head Temperature checklist – worth mentioning/reviewing

7. Hydraulic Malfunction

- A. General Brake Failure Procedures – Verify with the POH
  - i. Symptoms of impending brake failure:
    - a. Gradual decrease in braking action after brake application
    - b. Noisy or dragging brakes
    - c. Soft or spongy pedals
    - d. Excessive brake travel
    - e. Weak braking action
  - ii. If braking action decreases during taxi/landing let up on the pedals then reapply with heavy pressure
  - iii. If brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure
  - iv. If one brake is weak or fails, use the other brake sparingly w/ opposite rudder to maintain direction
  - v. If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking
- B. POH Checklists
  - i. Section 3 Emergency Procedures
    - a. Perspective: Left/Right Brake Over-Temperature Annunciation
    - b. Perspective +: Brake Temp Warning
  - ii. Section 3A, Abnormal Procedures
    - a. Brake Failure During Taxi
    - b. Landing with Failed Brakes

8. Electrical Malfunction

- A. Procedures, checklists, and text vary by model
  - i. Section 3A, Abnormal Procedures – Review the applicable procedures
- B. G1 / G2 (same checklist titles, but different procedures and text)
  - i. Alternator Failure
  - ii. Low Volts Warning Light Illuminated
- C. Perspective
  - i. Section 3, Emergency Procedures
    - a. High Voltage on Main Bus 1 / 2
    - b. High or Low Voltage on Essential Bus
  - ii. Section 3A, Abnormal Procedures
    - a. Low Voltage on Main Bus 1/2
    - b. Battery 1 Current Sensor
    - c. Low Alternator 1/2 Output
- D. Perspective +
  - i. Section 3, Emergency Procedures
    - a. M BUS 1 / 2 Warning
    - b. ESS Bus Warning
  - ii. Section 3A, Abnormal Procedures
    - a. M Bus 1 / 2 Caution

        b. Batt 1 Caution
        c. Alt 1 / 2 Caution (Failure)

9. Induction Icing

- A. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
    - i. Ice can also form on the exterior of the airplane, and clog the air intake openings
- B. Flight into known icing conditions is prohibited
- C. Section 3A, Abnormal Procedures
    - i. Inadvertent Icing Encounter
- D. If unrecognized, a rough running engine may be the first indication of induction icing
    - i. Engine Partial Power Loss checklist might be used
    - ii. Also opens the alternate induction air but does not include pitot/cabin heat, windshield defrost
    - iii. Once recognized, also run the Inadvertent Icing Encounter checklist

10. Door or Window Opening in Flight

- A. General information (verify with POH)
    - i. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following:
        - a. Concentrate on flying, an open door seldom compromises the ability of the plane to fly
        - b. Do not rush to land the plane if the door opens during lift off
            - Climb to normal pattern altitude, fly a normal pattern, make a normal landing
        - c. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
        - d. Most doors will not stay open, they will usually bang open then settle partially closed
            - A slip toward the door may open it wider, and a slip away may push it closed
- B. Section 3A, Abnormal Procedures
    - i. Review Door Open in Flight checklist

11. Inoperative or "Runaway" Trim

- A. Any failure or malfunction of the electric trim can be overridden by use of the control yoke
    - i. Basic process – Maintain control, turn off and de-power the system, fly the plane
- B. Section 3A, Abnormal Flight Procedures
    - i. Electric Trim/Autopilot Failure checklist

12. Flap Malfunction

- A. General Info – Total Flap Failure
    - i. Necessitates a no flap approach and landing
        - a. Requires substantially more runway than normal (as much as 50% more)
        - b. Airplane must be flown in a relatively nose-high attitude as compared to flaps extended
            - Can make the runway difficult to see
        - c. A wider, longer pattern may be required to avoid diving to lose altitude & building airspeed
        - d. Airplane will tend to float considerably during roundout
- B. Asymmetric (Split) Flap General Info (verify with POH)
    - i. A situation in which one flap deploys/retracts while the other remains in position
    - ii. The problem is indicated by a pronounced roll toward the wing with the least flap deflection
    - iii. Countering
        - a. Countered with opposite aileron
        - b. The yaw caused by the additional drag on the extended flap side will require opposite rudder
            - Aileron and opposite rudder results in a crossed control situation
        - c. Almost full aileron may be necessary at the reduced airspeed to maintain wings level
            - Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
                - a The additional roll control to counteract the cross-wind may not be available
    - iv. Be aware of the differing stall speeds of each wing

a. The wing with the retracted flap will stall much earlier - possible crossed control stall condition
v. Approach and landing should be flown at a higher-than-normal airspeed

C. SR20 Flap Malfunction Checklists
   i. Normal Procedures
      a. Landing with less than full flaps is recommended only if the flaps fail to deploy or to extend glide distance due to engine malfunction
         - Use power to achieve a normal glidepath and low descent rate when at 50% or 0% flaps
         - Maintain published speeds for the flap setting
            a See Section 4, Normal Procedures, Airspeeds for Normal Operation, Landing Approach
         - Adjust and account for longer landing roll
   ii. G1 / G2
      a. No specific flap checklists
   iii. Perspective
      a. Flap System Exceedance
   iv. Perspective +
      a. Flaps Overspeed Caution
      b. Takeoff Flaps Caution
      c. Flaps Climb Advisory

13. Pressurization Malfunction

A. Not applicable for the SR20, but in general, descend and/or use supplemental oxygen
   i. An emergency descent may be required
   ii. Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. DA40

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Smoke, Fire, or both, during Ground or Flight Operations 2. Rough Running Engine or Partial Power Loss 3. Loss of Engine Oil Pressure 4. Fuel Starvation 5. Engine Overheat 6. Hydraulic Malfunction 7. Electrical Malfunction 8. Induction Icing 9. Door or Window Opening in Flight 10. Inoperative or "Runaway" Trim 11. Flap malfunction 12. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. **Smoke, Fire, or Both, During Ground or Flight Operations**
   A. Ground Smoke/Fire
      i. Engine Fire when Starting on the Ground:
         a. Fuel Tank Selector: Off
         b. Cabin Heat: Off
         c. Brakes: Apply
         After standstill:
         d. Throttle: Max Power
         e. Master Switch (Alt/Bat): Off
         When engine has stopped:
         f. Ignition Switch: Off
         g. Canopy: Open
         h. Airplane: Evacuate immediately
      ii. Electrical Fire with Smoke on the Ground
         a. Master Switch (Alt/Bat): Off
         If the engine is running:
         b. Throttle: Idle
         c. Mixture Control Lever: Lean – shut off engine
         When the engine has stopped:
         d. Ignition Switch: Off
         e. Canopy: Open
         f. Airplane: Evacuate immediately
   B. Smoke and Fire During Takeoff
      i. If Takeoff can Still be Aborted
         a. Throttle: Idle
         b. Cabin Heat: Off
         c. Brakes: Apply – bring the aircraft to a stop

d. After Stopping continue with Smoke and Fire on the Ground checklist

ii. If Takeoff Cannot be Aborted

a. Cabin Heat: Off

b. If possible, fly along a short-cut traffic pattern and land on the airfield

Warning: If the takeoff can no longer be aborted and a safe height has not been reached, then a straight-ahead emergency landing should be carried out. Turning back can be fatal.

c. Airspeed:

- 74 KIAS (2646 lb)
- 72 KIAS (2235 lb)
- 66 KIAS (2205 lb)
- 59 KIAS (1874 lb)

After climbing to a height from which the selected landing area can be reached safely:

d. Fuel Tank Selector: Off

e. Electrical Fuel Pump: Off

f. Cabin Heat: Off

g. Master Switch (Alt/Bat): Off

h. Emergency Windows: Open if required

i. Carry out emergency landing with engine off. Allow for increased landing distance due to the flap position

Caution: In the case of extreme smoke development, the front canopy can be unlatched during flight to improve ventilation. Flight characteristics will not be affected significantly.

C. In-Flight Smoke/Fire

i. General

a. In any fire, it is essential the source is discovered first

b. Prepare to land the aircraft without delay while completing the fire suppression and /or smoke evacuation procedures. If it cannot be visually verified that the fire has been completely extinguished, land immediately at the nearest suitable airfield or landing site

ii. Engine Fire in Flight

a. Usually caused by a failure allowing a combustible substance to contact a hot surface

b. Checklist:

- Cabin Heat: Off
- Select appropriate emergency landing field

When it Seems Certain the Landing Field Will Be Reached:

- Fuel Tank Selector: Off
- Throttle: Max Power
- Electrical Fuel Pump: Off
- Master Switch (Alt/Bat): On
- Emergency Windows: Open if required
- Carry out emergency landing with engine off

Note: In case of extreme smoke, the front canopy may be unlatched in flight to improve ventilation. Flight characteristics will not be affected significantly

c. Keep in mind that

- There may be severe structural damage and control could be lost at any time
- The airplane may still be on fire and susceptible to explosion
- The airplane is expendable and the only thing that matters is the safety of those onboard

iii. Electrical Fire with Smoke in Flight

a. Indication is usually the distinct odor of burning insulation (acrid smell)

b. Checklist:

- Emergency Switch: On (if installed)
- Master Switch (Alt/Bat): Off
- Cabin Heat: Off
- Emergency Windows: Open, if required
- Land at an appropriate airfield as soon as possible

Note: Switching off the Master (Alt/Bat) will lead to total failure of all electronic equipment, however by switching the emergency switch On (IFR model DA40s), the emergency battery will supply power to the attitude gyro and flood light

In case of extreme smoke, the front canopy can be unlatched during flight for improved ventilation. Flight characteristics will not be affected significantly

iv. Cabin Fires

a. Usually result from:
- Careless smoking on the part of the pilot and/or passengers
- Electrical system malfunctions
- Heating system malfunctions

b. Two immediate demands:
- Attack the fire
- Get the airplane safely on the ground as quickly as possible

2. Rough Running Engine or Partial Power Loss

A. Engine Running Roughly Checklist:

Warning: An engine which is running very roughly can lead to the loss of the propeller. If the engine is running roughly, operation should only be continued if there is no other alternative

i. Airspeed:
  a. 76 KIAS (2646 lb)
  b. 73 KIAS (2535 lb)
  c. 68 KIAS (2205 lb)
  d. 60 KIAS (1874 lb)

ii. Electrical Fuel Pump: Check On

iii. Fuel Tank Selector: Check selected tank

iv. Engine Instruments: Check

v. Throttle: Check

vi. RPM Lever: Check

vii. Mixture Control Lever: Set for smooth running

viii. Alternate Air: Check (only if the electronic ignition control unit is installed)

ix. Ignition Switch: Check Both

x. Ignition Circuit Breaker (IGN): Pull (only if the electronic ignition control unit is installed); if rough running is cleared by doing this, the circuit breaker should remain open

xi. Throttle/Mixture/RPM: Try various settings

Warning: If the problem does not clear itself immediately, and the engine is no longer producing sufficient power, then an emergency landing should be carried out

3. Loss of Engine Oil Pressure

A. Loss of Oil Pressure Checklist

i. Check oil pressure warning light and oil pressure indicator

ii. Check oil temperature

  a. If the oil pressure drops below the green sector and the oil temperature is normal

(oil pressure warning light does not illuminate or flash):
- Monitor the oil pressure warning light - it is probable that the oil pressure indication is defective
- Monitor the oil and cylinder head temperatures

b. If the oil pressure indication drops below the green sector while the oil or cylinder head temperature is rising, or the oil pressure warning light illuminates or flashes (or both of these happen together):
- Reduce the engine power to the minimum required
- Land as soon as possible
- Be prepared for engine failure and emergency landing

c. Oil pressure trending to zero, combined with vibration, loss of oil, possibly unusual metallic noise and smoke:
- A mechanical failure in the engine is apparent
- Shutoff the engine immediately and carry out Emergency Landing with Engine Off checklist

B. High Oil Pressure Checklist

i. Check oil temperature

a. If the oil temperature is normal, it is probable that the fault lies in the oil pressure indication, which should thus be ignored (the aircraft should be serviced)

4. Fuel Starvation

A. Normally indicated by a rough running engine, and can be caused by blocked lines or empty tanks

i. Most likely course of action is to run the Engine Running Roughly checklist

ii. In the case of fuel starvation, run the Emergency Landing with Engine Off checklist

B. Low Fuel Pressure with the Electrical Fuel Pump Set to On Checklist

i. Fuel Flow: Check

a. If the fuel flow is high, there is possible a leak. Land at the nearest suitable airfield

b. If the fuel flow is in the green sector and the engine is running smoothly, the likely cause is a defective fuel pressure indication, which should thus be ignored (the aircraft should be serviced)

c. Monitor the engine for power loss and rough operation that could indicate fuel starvation. If the engine is no longer producing sufficient power, then an emergency landing should be carried out

C. Emergency Landing with Engine Off Checklist

a. Adjustable Backrests (if installed): Upright

b. Select suitable landing area. If no level landing area is available, a landing on an upward slope should be sought

c. Consider wind

d. Approach: If possible, fly a short-cut rectangular pattern. Inspect the landing area on the downwind leg. Continue to consider/adjust for wind

e. Airspeed
- 76 KIAS (2646 lb)
- 73 KIAS (2535 lb)
- 68 KIAS (2205 lb)
- 60 KIAS (1874 lb)

f. If Time Allows: Advice ATC

g. Fuel Tank Selector: Off

When it is certain that the landing field will be reached:

h. Flaps: LDG
i. Safety Harnesses: Tighten

Caution: If sufficient time is remaining, the risk of fire in the event of a collision with obstacles can be reduce as follows:

- Ignition Switch: Off
- Master Switch (Alt/Bat): Off

j. Touchdown: Lowest possible airspeed

5. Engine Overheat

A. The oil temperature gauge is the primary instrument in determining if the engine is overheating

B. Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

C. High Oil Temperature

i. Check cylinder head and exhaust gas temperature

a. If neither of these is high, it is probable that the fault lies in the oil temperature indication. The aircraft should be serviced. A stable oil temperature indication of 26° F or 317° F suggests a failure of the oil temperature sensor

b. If the cylinder head temperature or exhaust gas temperature is also high:

- Check oil pressure. If the oil pressure is low, proceed with the Loss of Oil Pressure Checklist
- If the oil pressure is in the green sector:
  a Check mixture setting, enrich mixture if necessary
  b Reduce power. If this produces no improvement, land at the nearest appropriate airfield

D. High Cylinder Head Temperature

i. Cylinder head temperature in yellow sector, or above:

a. Check mixture setting, enrich mixture if necessary

b. Check oil temperature

- If the oil temperature is also high:
  a Check oil pressure. If the oil pressure is low, proceed with the Loss of Oil Pressure Checklist
  b If the oil pressure is in the green sector:
    1. Reduce power; if this produces no improvement, land at the nearest appropriate airfield
    2. Be prepared for possible emergency landing

6. Hydraulic Malfunction

A. General Brake Failure Procedures – Not in the POH

i. Symptoms of impending brake failure:

a. Gradual decrease in braking action after brake application

b. Noisy or dragging brakes

c. Soft or spongy pedals

d. Excessive brake travel

e. Weak braking action

ii. If during taxi or landing roll, braking action decreases let up on the pedals and the reapply the brakes with heavy pressure

iii. If the brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure

iv. If one brake becomes weak or fails, use the other brake sparingly while using opposite rudder, as required, to offset the good brake

v. If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking

7. Electrical Malfunction

A. Complete Failure of the Electrical System

i. A total failure of the electrical system is extremely unlikely

ii. If a total failure should occur, all circuit breakers should be checked, pulled and reset. If this does not help:

a. Set Emergency switch to On (if installed)

b. When necessary, use the flood light for lighting the instruments as well as levers and switches, etc.

c. Set power based on lever positions and engine noise

d. Prepare landing with flaps in the given position

e. Land at the nearest appropriate airfield

B. Alternator Failure

i. Indicated by an illuminated or flashing alternator warning light

ii. Alternator Failure During Flight:

a. Circuit Breakers: Check; if all are OK, proceed with step 2

b. Electrical Equipment: Switch Off all equipment which is not needed

c. Voltmeter: Check regularly

Caution: Items of equipment not needed for safe operation and secure landing of the aircraft can be switched off with the Essential Bus switch (if installed). When the essential bus switch is on, only the following items are supplied with battery power for at least 30 minutes:

- NAV/COM 1
- Transponder
- Attitude Gyro
- VM 1000 Engine Instrument
- Annunciator Panel
- GPS
- Landing Light
- Pitot Heat
- Flaps

C. Low Voltage Caution on the Ground

i. Engine Speed: 1200 RPM

ii. Electrical Equipment: Off

iii. Ammeter: Check

a. If the caution light does not go out, and the ammeter flashes and reads zero:

- Terminate flight preparation

D. Low Voltage Caution in Flight

i. Electrical Equipment: Off

ii. Ammeter: Check

iii. If the caution light does not go out, and the ammeter flashes and reads zero:

a. Follow the Alternator Failure Checklist

8. Induction Icing

A. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
   i. Ice can also form on the exterior of the airplane, and clog the air intake openings

B. Unintentional Flight into Icing Checklist
   i. Leave the icing area (change altitude or turning back, to reach zones with a higher ambient temperature)
   ii. Pitot Heat: On
   iii. Cabin Heat: On
   iv. Air Distributor: Up
   v. RPM: Increase to prevent ice build-up on the propeller blades
   vi. Alternate Air: Open
   vii. Emergency Window(s): Open, if required
      Caution: Ice build-up increases the stalling speed. If required for safety, engine speeds up to 2700 RPM are admissible without time limit
   viii. ATC: Advise
   Caution: When the Pitot Heat fails, and the alternate static valve is installed:
   ix. Alternate Static Valve: Open
   x. Emergency Window(s): Close

9. Door or Window Opening in Flight

A. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following:
   i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
   ii. Do not rush to land the plane if the door opens during lift off
      a. Climb to normal pattern altitude, fly a normal pattern, make a normal landing
   iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
   iv. Most doors will not stay open, they will usually bang open then settle partially closed
      a. A slip toward the door may open it wider, and a slip away may push it closed

B. Door Warning Light On
   i. Airspeed: Reduce immediately
   ii. Canopy: Check visually if closed
   iii. Rear Passenger Door: Check visually if closed
   Canopy Unlocked
   iv. Airspeed: Below 140 KIAS
   v. Land at the next suitable airfield
   Rear Door Unlocked
   vi. Airspeed: Below 140 KIAS
   vii. Land at the next suitable airfield
   Warning: Do not try to lock the rear door in flight. The safety latch may disengage, opening the door. Usually this results in a separation of the door of the airplane
   Note: If the rear door has been lost, the aircraft can be safely flown to the next suitable airfield

10. Inoperative or "Runaway" Trim

A. Checklist:
   i. Control Stick: Grasp firmly and regain aircraft control
   ii. AP DISC Switch: Press and hold throughout recovery
   iii. Trim: Retrim the aircraft manually as required

iv. Autopilot Circuit Breaker: Pull
The Avionic Master switch may be used as an alternate means of removing all power from the autopilot and electric trim system. If necessary, perform steps i-iii, then turn the Avionic Master switch off before locating and pulling the autopilot circuit breaker. Turn the Avionic Master switch On as soon as possible to restore power to all other avionics equipment. Primary attitude, airspeed and altitude instruments will remain operational at all times.

11. Flap Malfunction

A. General
 i. Total Flap Failure
  a. This will necessitate a no flap approach and landing
   - This will require substantially more runway than normal (as much as 50% more)
   - The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
    a This can make the runway difficult to see
   - A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
   - The airplane will tend to float considerably during roundout
  b. If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle
 ii. Asymmetric (Split) Flap
  a. A situation in which one flap deploys/retracts while the other remains in position
  b. The problem is indicated by a pronounced roll toward the wing with the least flap deflection
  c. Countering
   - Countered with opposite aileron
   - The yaw caused by the additional drag on the extended flap side will require opposite rudder
    a Aileron and opposite rudder results in a crossed control situation
   - Almost full aileron may be necessary at the reduced airspeed to maintain wings level
    a Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
     1. The additional roll control to counteract the cross-wind may not be available
  d. Be aware of the differing stall speeds of each wing
   - The wing with the retracted flap will stall much earlier - possible crossed control stall condition
  e. Approach and landing should be flown at a higher than normal airspeed

B. DA40 Failures in Flap Operating System
 i. Failure in Position Indication or Function:
  a. Check flap position visually
  b. Keep airspeed in white sector
  c. Re-check all position of the flap switch
 ii. Modified Approach Procedure Depending on the Available Flap Setting:
  a. Only Up or T/O available
   - Airspeed:
    a 76 KIAS (2646 lb)
    b 73 KIAS (2535 lb)
    c 68 KIAS (2205 lb)
    d 60 KIAS (1874 lb)
   - Land at a flap approach angle, use throttle to control aircraft speed and rate of descent
  b. Only LDG available
   - Perform normal landing

12. Pressurization Malfunction

A. Not applicable for the DA40, but in general, descend or use supplemental oxygen

i. Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Piper Archer II (PA-28-181)

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Smoke, Fire, or both, during Ground or Flight Operations 2. Rough Running Engine or Partial Power Loss 3. Loss of Engine Oil Pressure 4. Fuel Starvation 5. Engine Overheat 6. Hydraulic Malfunction 7. Electrical Malfunction 8. Induction Icing 9. Door or Window Opening in Flight 10. Inoperative or “Runaway” Trim 11. Flap Malfunction 12. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP’s Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP’s Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. Smoke, Fire, or Both, During Ground or Flight Operations

A. Ground Operations
  - i. Engine Fire During Start - Usually the result of overpriming
    - a. Procedures
      - The first attempt to extinguish the fire is to try to start the engine and draw the excess fuel back into the induction system
      - Fire Prior to Engine Start – Move the mixture to idle cut-off, open the throttle and crank the engine
        - a This is an attempt to draw the fire back into the engine
      - If the Engine has Started – Continue operating to try to pull the fire into the engine
      - In either case (above), if the fire continues more than a few seconds, the fire should be extinguished by the best available external means
        - a The fuel selector valves should be off and the mixture at idle cut-off if an external fire extinguishing method is to be used

B. Flight Operations
  - i. General
    - a. Presence of fire is noted through smoke, smell, and/or heat in the cabin
    - b. The source of the fire must be promptly identified. Check for the source of the fire first
      - Identifiers like instrument readings, characters of the smoke (smell, color, location), etc.
  - ii. Electrical Fire in Flight
    - a. Fuel Selector: Off
    - b. Master switch: Off
    - c. Vents: Open
    - d. Cabin Heat: Off
    - e. Land as soon as practicable
  - iii. Engine Fire in Flight

- Fuel Selector: Off
- Throttle: Closed
- Mixture: Idle Cut-Off
- Electrical Fuel Pump: Check Off
- Heater and Defroster: Off
- If radio communication is not required, Master Switch: Off
- Proceed with Power Off Landing Procedure

2. Rough Running Engine or Partial Power Loss

A. General

i. Engine roughness is usually due to carburetor icing which is indicated by a drop in RPM, and may be accompanied by a slight loss of airspeed or altitude

a. If too much ice is allowed to accumulate, restoration of full power may not be possible; therefore, prompt action is required

B. Procedure

i. Carburetor Heat: On

a. RPM will decrease slightly and roughness will increase

b. Wait for a decrease in engine roughness or an increase in RPM, indicating ice removal

If roughness continues after one minute:

ii. Carburetor Heat: Off

iii. Mixture: Adjust for maximum smoothness

iv. Electrical Fuel Pump: On

v. Fuel Selectors: Switch Tanks

a. To see if fuel contamination is the problem

vi. Engine Gauges: Check (if any indications are abnormal, proceed accordingly)

vii. Magneto Switch: L then R then Both

a. If operation is satisfactory on either magneto, proceed on that magneto at reduced power, with mixture full rich, to a landing at the first available airport

viii. Prepare for power off landing

3. Loss of Engine Oil Pressure

A. General

i. Can be a partial or total loss of oil pressure

a. Partial Loss

- Usually indicates a malfunction in the oil pressure regulating system, and a landing should be made as soon as possible to investigate the cause and prevent engine damage

b. Complete Loss

- May signify oil exhaustion or may be the result of a faulty gauge
- In either case, proceed toward the nearest airport and be prepared for a forced landing. If the problem is not a pressure gauge malfunction, the engine may stop suddenly
  - a Maintain altitude until such time as a dead stick landing can be accomplished
  - b Don't change power settings unnecessarily, this may hasten complete power loss
- Depending on the circumstances, it may be advisable to make an off airport landing while power is still available, particularly if other indication of actual oil pressure loss, such as sudden increases in temperatures, or oil smoke, are apparent, and an airport is not close

B. Procedures

i. Land as soon as possible and investigate cause

ii. Prepare for power off landing

4. **Fuel Starvation**
   A. Normally indicated by a rough running engine, and can be caused by blocked fuel lines or empty tanks
      i. Unless recognized immediately, the most likely course of action is to run the Engine Roughness checklist, or Engine Power Loss in Flight checklist
      ii. In the case of fuel starvation, a power off landing will be necessary using the Power Off Landing checklist
   B. Plan ahead while on the ground, and monitor fuel while in flight to prevent fuel starvation
      i. If at any point during flight the fuel required is not in line with the fuel available create a new plan. Divert immediately if necessary, don't rely on hope!
5. **Engine Overheat**
   A. General
      i. The oil temperature gauge is the primary instrument in determining if the engine is overheating
         a. Watch the oil pressure gauge for an accompanying loss of pressure
         b. A steady rise in oil temperature is a sign of trouble. Land at the nearest airport and let a mechanic investigate the problem
      ii. Rising oil temperature may be the result of a low oil level, and obstruction in the oil cooler, damaged or improper baffle seals, a defective gauge, or other causes
   B. High Oil Temperature Procedures
      i. Land at the nearest airport and investigate the problem
      ii. Prepare for power off landing
   C. Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

6. **Hydraulic Malfunction**
   A. General Brake Failure Procedures – Not in the POH
      i. Symptoms of impending brake failure:
         a. Gradual decrease in braking action after brake application
         b. Noisy or dragging brakes
         c. Soft or spongy pedals
         d. Excessive brake travel
         e. Weak braking action
      ii. If during taxi or landing roll, braking action decreases let up on the pedals and the reapply the brakes with heavy pressure
      iii. If the brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure
      iv. If one brake becomes weak or fails, use the other brake sparingly while using opposite rudder, as required, to offset the good brake
      v. If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking
7. **Electrical Malfunction**
   A. Alternator Failure
      i. Ammeter: Check to verify inoperative alternator
         a. Loss of alternator output is detected through zero reading on the ammeter. Before executing the following procedure, ensure that the reading is zero and not merely low by actuating an electrically powered device (like the landing light). If no increase in

the ammeter reading is noted, alternator failure can be assumed

If ammeter shows zero:

ii. ALT switch: Off

Reduce electrical loads to minimum:

iii. ALT circuit breaker: Check and reset as required

iv. ALT switch: On

a. Switching the alternator off and then on attempts to reset the overvoltage relay. If the problem was caused by a momentary overvoltage condition (16.5 volts or more), this procedure should return the ammeter to normal operation.

If power not restored (ammeter still indicates zero), or the alternator will not remain reset:

v. ALT switch: Off

If alternator output cannot be restored, reduce electrical loads and land as soon as practical. The battery is the only remaining source of electrical power

B. Electrical Overload
   i. If abnormally high alternator output is observed (more than 20 amps above known electrical load for the operating conditions) it may be caused by a low battery, a battery fault, or other abnormal electrical load
      a. If the cause is a low battery, the indication should begin to decrease toward normal within 5 minutes
      b. If the condition persists, attempt to reduce the load by turning off non-essential equipment

C. Electrical Overload Checklist – For aircraft with interlocked Bat and Alt switch operation

i. Electrical load: Reduce

If alternator loads are reduced:

ii. ALT switch: Off

iii. Land as soon as practical. The battery is the only remaining source of power. Anticipate complete electrical failure

   iv. Expanded POH Info: When the electrical load cannot by reduced, turn the ALT switch Off and land as soon as practical

D. Electrical Overload Checklist – For aircraft with separate Bat and Alt switch operation

i. Alt switch: On

ii. Bat switch: Off

If alternator loads are reduced:

iii. Electrical load: Reduce to minimum

iv. Land as soon as practical

If alternator loads are not reduced:

v. Alt switch: Off

vi. Bat switch: As required

vii. Land as soon as possible. Anticipate complete electrical failure

   viii. Expanded POH Info: Turn the Bat switch off and the ammeter should decrease. Turn the Bat switch on and continue to monitor the ammeter. If the alternator output does not decrease within 5 minutes, turn the Bat switch off and land as soon as practical. All electrical loads are being supplied by the alternator.

8. Induction Icing

A. General
   i. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
      a. Ice can also form on the exterior of the airplane, and clog the air intake openings
   ii. Induction icing can happen under certain moist atmospheric conditions at temperatures between -5°C and 20°C, even in summer weather
      a. This is due to the high air velocity through the carburetor venturi and the absorption of heat from this air by vaporization of the fuel

- iii. Carb heat should be set to full on whenever used
  - a. Partial carb heat may melt part of the ice, which will refreeze in the intake system
- B. Carburetor Icing Checklist

i.	Carburetor Heat: On
ii.	Mixture: Adjust for maximum smoothness

- C. If the pilot is unaware of icing, the Engine Roughness checklist will also lead to turning on the carb heat in case induction icing is the cause of the problem

9. Door or Window Opening in Flight

- A. POH Amplified Emergency Procedures
  - i. The cabin door is double latched so the changes of it opening during flight are remote
    - a. However, a partially open door will not affect the normal flight characteristics of the aircraft and a normal landing can be made with the door open
    - b. If both latches are open, the door will trail slightly open, and airspeed will be reduced slightly
- B. Open Door Checklist

i.	To close the door in flight:
	a. Slow the aircraft to 87 KIAS
	b. Cabin Vents: Close
	c. Storm Window: Open
	d. If upper latch is open: Latch
	e. If side latch is open: Pull on armrest while moving latch handle to latched position
	f. If both latches are open: Latch side latch then top latch

- C. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following general information:
  - i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
  - ii. Do not rush to land the plane if the door opens during lift off
    - a. Climb to normal pattern altitude, fly a normal pattern, make a normal landing
  - iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
    - a. The Piper Archer does have a checklist to close the door in flight. Do not lose control of the aircraft trying to close the door. Fly the plane first.
  - iv. Most doors will not stay open, they will usually bang open then settle partially closed
    - a. A slip toward the door may open it wider, and a slip away may push it closed

10. Inoperative or "Runaway" Trim

- A. In case of Electric Trim Malfunction (if installed)

i.	AP DISC/TRIM INTER Switch: Press and hold throughout recovery
ii.	Pitch Trim circuit breaker: Pull
iii.	Aircraft: Retrim manually
When disconnecting the autopilot after a trim malfunction, hold the control wheel firmly. Up to 45 lbs. of force on the control wheel may be necessary to hold the aircraft level	

11. Flap Malfunction

- A. General (no specific procedures in the Archer POH)
  - i. Total Flap Failure
    - a. This will necessitate a no flap approach and landing
      - This will require substantially more runway than normal (as much as 50% more)
      - The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
        - a This can make the runway difficult to see
      - A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
      - The airplane will tend to float considerably during roundout
    - b. If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle

ii. Asymmetric (Split) Flap
   a. A situation in which one flap deploys/retracts while the other remains in position
   b. The problem is indicated by a pronounced roll toward the wing with the least flap deflection
   c. Countering
      - Countered with opposite aileron
      - The yaw caused by the additional drag on the extended flap side will require opposite rudder
         a Aileron and opposite rudder results in a crossed control situation
      - Almost full aileron may be necessary at the reduced airspeed to maintain wings level
         a Therefore, do not attempt to land with a cross-wind from the side of the deployed flap
            1. The additional roll control to counteract the cross-wind may not be available
   d. Be aware of the differing stall speeds of each wing
      - The wing with the retracted flap will stall much earlier - possible crossed control stall condition
   e. Approach and landing should be flown at a higher than normal airspeed

12. Pressurization Malfunction

A. Not applicable for the Piper Archer, but in general, descend or use supplemental oxygen
   i. Hypoxia is the primary danger of decompression

Conclusion:
Brief review of the main points
Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Piper Archer III (PA-28-181)

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. General Info 2. Smoke, Fire, or both, during Ground or Flight Operations 3. Rough Running Engine or Partial Power Loss 4. Loss of Engine Oil Pressure 5. Fuel Starvation 6. Engine Overheat 7. Hydraulic Malfunction 8. Electrical Malfunction 9. Induction Icing 10. Door or Window Opening in Flight 11. Inoperative or “Runaway” Trim 12. Flap Malfunction 13. Pressurization Malfunction
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Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. **General Info**
   A. Review 3.1 General in the POH
      i. CAS Messages
      ii. PFD Annunciations & Alerts
      iii. Aural Alerts
      iv. Terminology (Land as soon as practical vs possible)
   B. Review 3.3 Airspeeds for Safe Operation
2. **Smoke, Fire, or Both, During Ground or Flight Operations**
   A. Ground Operations
      i. Engine Fire During Start - Usually the result of overpriming
         a. Reference checklist in Section 3 of the POH Flight Operations
         b. Intent is to draw the fire back into the engine
   B. Flight Operations
      i. General
         a. Presence of fire is noted through smoke, smell, and/or heat in the cabin
         b. Essential that the source of the fire be promptly identified
            - Identifiers like instrument readings, characters of the smoke (smell, color, location), etc.
            - Pilot judgement and a thorough understanding of the systems is critical
      ii. Engine Fire in Flight
         a. Reference checklist in Section 3 of the POH Flight Operations
      iii. Electrical Fire in Flight
         a. Reference checklist in Section 3 of the POH Flight Operations
3. **Rough Running Engine or Partial Power Loss**
   A. General Considerations

Possible Causes	Corrective Action
Improper mixture	Adjust mixture for smooth op
Defective ignition or valves	Consult maintenance personnel
Detonation / preignition	Reduce power, enrich mixture, land as soon as practical

Induction air leak	Reduce power. Consult maintenance
Plugged fuel nozzle	Reduce power. Consult maintenance
Excessive fuel pressure / fuel flow	Lean mixture

B. Engine Roughness – Reference checklist in Section 3 of the POH Flight Operations
   i. May be caused by blockage in the injector nozzles, induction system icing, or ignition problems
   ii. Follow the procedures, check the gauges for abnormal readings and proceed accordingly
C. Engine Power Loss in Flight – Reference checklist in Section 3 of the POH Flight Operations
   i. Complete power loss is usually caused by fuel interruption

4. Loss of Engine Oil Pressure

A. Checklist Information
   i. Can be a partial or total loss of oil pressure
      a. Partial Loss
         - Usually indicates a malfunction in the oil pressure regulating system,
         - Landing should be made as soon as possible to investigate the cause and prevent damage
      b. Complete Loss
         - May signify oil exhaustion or may be the result of a faulty gauge
         - In either case, proceed toward the nearest airport and be prepared for a forced landing
         - If the problem is not a pressure gauge malfunction, the engine may stop suddenly
            a Maintain altitude until such time as a dead stick landing can be accomplished
            b Don't change power settings unnecessarily, this may hasten complete power loss
B. Oil Pressure Checklist – Reference checklist in Section 3 of the POH Flight Operations

5. Fuel Starvation

A. Normally indicated by a rough running engine
   i. Unless recognized, likely to run Engine Roughness checklist, or Engine Power Loss in Flight checklist
      a. Engine Power Loss In Flight – Reference checklist in Section 3 of the POH Flight Operations
         - Complete power loss is usually caused by fuel flow interruption
         - Water in the fuel may take time to clear – allowing the prop to windmill may restore power
         - If the selected tank is empty, it can take up to 10 seconds after switching tanks to restart
      b. Engine Roughness – Reference checklist in Section 3 of the POH Flight Operations
         - May be caused by blockage in the injector nozzles
         - Adjusting mixture, turning on electric fuel pump & swapping tanks may help with fuel issues
   ii. If power is not regained, a power off landing will be necessary using the Power Off Landing checklist
B. Plan ahead while on the ground and monitor fuel while in flight to prevent fuel starvation
   i. If at any point the fuel remaining does not reasonably resemble the plan, assess the situation
   ii. If necessary, divert immediately – don't rely on hope!

6. Engine Overheat

A. General
   i. Oil temperature gauge is the primary instrument in determining if the engine is overheating
      a. Watch the oil pressure gauge for an accompanying loss of pressure
   ii. General Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

B. Oil Temperature – Reference checklist in Section 3 of the POH Flight Operations

i. Causes: Low oil level, oil cooler obstruction, damager or improper baffle seals, faulty indication, etc.
ii. Land as soon as possible and have the cause investigated

7. Hydraulic Malfunction

A. General Brake Failure Procedures – Not in the POH
   i. Symptoms of impending brake failure:
      a. Gradual decrease in braking action after brake application
      b. Noisy or dragging brakes
      c. Soft or spongy pedals
      d. Excessive brake travel
      e. Weak braking action
   ii. If braking action decreases, let up on the pedals and the reapply with heavy pressure
   iii. If the brakes become spongy or pedal travel increases, pumping the pedals should build pressure
   iv. If one brake is weak or fails, use the other sparingly with opposite rudder to offset the good brake
   v. If both brakes have failed, select the longest landing surface available
      a. Make a controlled landing w/o excessive float – slow straight ahead with aerodynamic braking

8. Electrical Malfunction

A. Alternator Failure
   i. If a momentary overvoltage caused the failure, resetting the ALTR switch should fix the problem
   ii. If the alternator does not reset, the battery is the primary source of power
      a. Essential Bus is only bus powered
      b. When the battery dies, the emergency battery should automatically activate
         - If it doesn't turn off BATT MASTR and ALTR switches
      c. About 30 mins of power
   iii. Alternator Failure – Reference checklist in Section 3 of the POH Flight Operations

B. Complete Electrical Failure
   i. Reference checklist in Section 3 of the POH Flight Operations
   ii. Inoperative Equipment while on Emergency Bus
      a. PFD, Engine instruments (except oil pressure), Com / Nav 1, Standby instrument, Audio panel, Avionics lighting/dimming

C. Emergency Battery Voltage
   i. Reference checklist in Section 3 of the POH Flight Operations
   ii. Complete electrical failure is imminent – Land as soon as possible

9. Induction Icing

A. General
   i. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
      a. Ice can also form on the exterior of the airplane, and clog the air intake openings
   ii. Induction system icing can lead to engine roughness

B. Engine Roughness Checklist
   i. Without a direct indication of icing, engine roughness is likely the first sign of the problem
   ii. Reference checklist in Section 3 of the POH Flight Operations
      a. Directs you to open the alternate air intake

10. Door or Window Opening in Flight

A. Open Door Checklist
   i. Reference checklist in Section 3 of the POH Flight Operations

B. General Information (POH takes precedence)
   i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
   ii. Do not rush to land the plane if the door opens during lift off

a. Climb to normal pattern altitude, fly a normal pattern, make a normal landing

iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it

a. The Piper Archer does have a checklist to close the door in flight. Do not lose control of the aircraft trying to close the door. Fly the plane first.

iv. Most doors will not stay open, they will usually bang open then settle partially closed

a. A slip toward the door may open it wider, and a slip away may push it closed

11. Inoperative or "Runaway" Trim

A. Electric Pitch Trim Failure

i. Reference checklist in Section 3 of the POH Flight Operations

B. Electric Pitch Trim Runaway

i. Reference checklist in Section 3 of the POH Flight Operations

ii. Basically, maintain control, disengage the autopilot/trim system and turn it off (pull CB)

iii. Fly first!

C. Autopilot Out-Of-Trim

i. Reference checklist in Section 3 of the POH Flight Operations

ii. Do not attempt to overpower the autopilot – the servos will oppose and trim opposite your input

12. Flap Malfunction

A. General (no specific procedures in the Archer POH)

i. Total Flap Failure

a. This will necessitate a no flap approach and landing

- Requires substantially more runway than normal (as much as 50% more)
- Flown in a relatively nose-high attitude as compared to flaps extended
  - a Can make the runway difficult to see
- Wider, longer pattern may be necessary to avoid diving to lose altitude & building up speed
- Tendency to float considerably during roundout

ii. Asymmetric (Split) Flap

a. A situation in which one flap deploys/retracts while the other remains in position

b. The problem is indicated by a pronounced roll toward the wing with the least flap deflection

c. Countering

- Countered with opposite aileron
- Yaw caused by the additional drag on the extended flap side will require opposite rudder
  - a Aileron and opposite rudder results in a crossed control situation
- Close to full aileron may be necessary at the reduced airspeed to maintain wings level
  - a Do not attempt to land with a crosswind from the side of the deployed flap
    1. Additional roll control to counteract the crosswind may not be available

d. Be aware of the differing stall speeds of each wing

- Wing with the retracted flap will stall earlier - possible crossed control stall condition

e. Approach and landing should be flown at a higher-than-normal airspeed

- Use POH published flaps speeds and adjust for the higher landing distance

13. Pressurization Malfunction

A. Not applicable for the Piper Archer, but in general, descend and/or use supplemental oxygen

i. Hypoxia is the primary danger of decompression

Conclusion:

Brief review of the main points

Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.C. Piper Arrow (PA-28R-201)

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to emergency procedures and be able to explain the proper procedures for certain situations based on the ACS/PTS.
Key Elements	1. Understand the Problem 2. Follow the Checklist 3. Safety of Those Onboard
Elements	1. Smoke, Fire, or both, during Ground or Flight Operations 2. Rough Running Engine or Partial Power Loss 3. Loss of Engine Oil Pressure 4. Fuel Starvation 5. Engine Overheat 6. Hydraulic Malfunction 7. Electrical Malfunction 8. Induction Icing 9. Door or Window Opening in Flight 10. Inoperative or "Runaway" Trim 11. Flap Malfunction 12. Pressurization Malfunction
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student can understand problems and why they may occur in the airplane. The student also can properly react to the emergency situations that have been discussed in a timely manner.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Wouldn't it be fun to be flying one day and experience a problem that you have no idea how to deal with? Of course not, that's why it's important to understand your equipment and the proper procedures associated.

Overview

Review Objectives and Elements/Key ideas

What

Systems and equipment malfunctions involve knowing how to handle problems that may occur in the airplane to provide as safe a flight as possible.

Why

The key to successful management of an emergency situation, and/or preventing a non-normal situation from progressing into a true emergency, is a thorough knowledge of, and adherence to, the necessary procedures.

How:

1. **Smoke, Fire, or Both, During Ground or Flight Operations**
   - A. Ground Operations
     - i. Engine Fire During Start - Usually the result of overpriming
       - a. Procedures
         - The first attempt to extinguish the fire is to try to start the engine and draw the excess fuel back into the induction system
         - Fire Prior to Engine Start – Move the mixture to idle cut-off, open the throttle and crank the engine
           - a This is an attempt to draw the fire back into the engine
         - If the Engine has Started – Continue operating to try to pull the fire into the engine
         - In either case (above), if the fire continues more than a few seconds, the fire should be extinguished by the best available external means
           - a The fuel selector valves should be off and the mixture at idle cut-off if an external fire extinguishing method is to be used
       - b. Checklist
         - Starter: Crank engine
         - Mixture: Idle cut-off
         - Throttle: Open
         - Electric Fuel Pump: Off
         - Fuel Selector: Off
         - Abandon if fire continues
   - B. Flight Operations
     - i. General
       - a. Presence of fire is noted through smoke, smell, and/or heat in the cabin
       - b. The source of the fire must be promptly identified. Check for the source of the fire first
         - Identifiers like instrument readings, characters of the smoke (smell, color, location), etc.
     - ii. Electrical Fire in Flight
       - a. BATT MASTR switch: Off

b. ALTR switch: Off
c. Vents: Open
d. Cabin Heat: Off
e. Land as soon as possible

iii. Engine Fire in Flight

a. Fuel Selector: Off
b. Throttle: Closed
c. Mixture: Idle Cut-Off
d. Electrical Fuel Pump: Check Off
e. Heater and Defroster: Off
f. Proceed with Power Off Landing Procedure

2. Rough Running Engine or Partial Power Loss

A. General
   i. Engine roughness may be caused by dirt in the injector nozzles, induction system icing, or ignition problems

B. Procedure

i. Mixture: Adjust for maximum smoothness
ii. Alternate Air: Open
iii. Electrical Fuel Pump: On
iv. Fuel Selectors: Switch Tanks
   a. To see if fuel contamination is the problem
v. Engine Gauges: Check (if any indications are abnormal, proceed accordingly)
vi. Magneto Switch: L then R then Both
   a. If operation is satisfactory on either magneto, proceed on that magneto at reduced power, with mixture full rich, to a landing at the first available airport
vii. If roughness persists, prepare for a precautionary landing/power off landing

3. Loss of Engine Oil Pressure

A. General
   i. Can be a partial or total loss of oil pressure
      a. Partial Loss
         - Usually indicates a malfunction in the oil pressure regulating system, and a landing should be made as soon as possible to investigate the cause and prevent engine damage
      b. Complete Loss
         - May signify oil exhaustion or may be the result of a faulty gauge
         - In either case, proceed toward the nearest airport and be prepared for a forced landing. If the problem is not a pressure gauge malfunction, the engine may stop suddenly
            a Maintain altitude until such time as a dead stick landing can be accomplished
            b Don't change power settings unnecessarily, this may hasten complete power loss
         - Depending on the circumstances, it may be advisable to make an off airport landing while power is still available, particularly if other indication of actual oil pressure loss, such as sudden increases in temperatures, or oil smoke, are apparent, and an airport is not close

B. Procedures

i. Land as soon as possible and investigate cause
ii. Prepare for power off landing

4. Fuel Starvation

A. Normally indicated by a rough running engine, and can be caused by blocked fuel lines or empty tanks
   i. The most probable cause of loss of fuel flow/pressure is either fuel depletion or failure of the engine driven fuel pump

a. If loss of fuel flow/pressure occurs, check that the fuel selector is on a tank containing fuel and turn on the electric fuel pump

ii. Unless recognized immediately, the most likely course of action is to run the Engine Roughness checklist, or Engine Power Loss in Flight checklist

a. If the engine roughness/failure was caused by fuel exhaustion, it may take up to 10 seconds for the empty fuel lines to fill with fuel and power to be restored

iii. In the case of fuel starvation, a power off landing will be necessary using the Power Off Landing checklist

B. Plan ahead while on the ground, and monitor fuel while in flight to prevent fuel starvation

i. If at any point during flight the fuel required is not in line with the fuel available create a new plan. Divert immediately if necessary, don't rely on hope!

5. Engine Overheat

A. General

i. The oil temperature gauge is the primary instrument in determining if the engine is overheating

a. Watch the oil pressure gauge for an accompanying loss of pressure

b. A steady rise in oil temperature is a sign of trouble. Land at the nearest airport and let a mechanic investigate the problem

ii. Rising oil temperature may be the result of a low oil level, and obstruction in the oil cooler, damaged or improper baffle seals, a defective gauge, or other causes

B. High Oil Temperature Procedures

i. Land at the nearest airport and investigate the problem

ii. Prepare for power off landing

C. Causes and Corrective Action

POSSIBLE CAUSES	CORRECTIVE ACTION
Low Oil	Reduce Power. Land ASAP
Oil Congealed in Cooler	Reduce Power. Land. Preheat Engine
Inadequate Engine Cooling	Reduce Power, Increase airspeed
Detonation or Preignition	Check Cylinder Head Temps/Enrich Mixture/Reduce MP
Obstruction in the Oil Cooler	Reduce Power. Land ASAP
Damaged or Improper Baffle Seals	Reduce Power. Land ASAP
Defective Gauge	Reduce Power. Land ASAP

6. Hydraulic Malfunction

A. General Brake Failure Procedures – Not in the POH

i. Symptoms of impending brake failure:

a. Gradual decrease in braking action after brake application

b. Noisy or dragging brakes

c. Soft or spongy pedals

d. Excessive brake travel

e. Weak braking action

ii. If during taxi or landing roll, braking action decreases let up on the pedals and the reapply the brakes with heavy pressure

iii. If the brakes become spongy or pedal travel increases, pumping the pedals should build brake pressure

iv. If one brake becomes weak or fails, use the other brake sparingly while using opposite rudder, as required, to offset the good brake

v. If both brakes have failed, select the longest landing surface available. Make a controlled landing without excessive float and slow the aircraft straight ahead with aerodynamic braking

7. Electrical Malfunction

A. Alternator Failure

i. Ammeter: Check to verify inoperative alternator

a. Loss of alternator output is detected through zero reading on the ammeter. Before executing the following procedure, ensure that the reading is zero and not merely low by actuating an electrically powered device (like the landing light). If no increase in the ammeter reading is noted, alternator failure can be assumed

If ammeter shows zero:

ii. ALTR switch: Off

Reduce electrical loads to minimum:

iv. ALTR FIELD circuit breaker: Check and reset as required

v. ALTR switch: On

  a. Switching the alternator off and then on attempts to reset the overvoltage relay. If the problem was caused by a momentary overvoltage condition (16.5 volts or more), this procedure should return the ammeter to normal operation.

If power not restored (ammeter still indicates zero), or the alternator will not remain reset:

vi. ALTR switch: Off

If alternator output cannot be restored, reduce electrical loads and land as soon as practical. The battery is the only remaining source of electrical power

B. Electrical Overload
   i. If abnormally high alternator output is observed (more than 20 amps above known electrical load for the operating conditions) it may be caused by a low battery, a battery fault, or other abnormal electrical load

C. Electrical Overload Checklist

i. BATT MASTR: Switch: Off

If ammeter reading does NOT decrease:

ii. ALTR Switch: Off

iii. Land as soon as possible. Use Emergency Landing Gear Extension to lower the gear

If ammeter reading DOES decrease:

iv. BATT MASTR Switch: On

v. Ammeter: Monitor

If ammeter reading does NOT begin to decrease within five minutes:

vi. BATT MASTR Switch: Off

vii. Land as soon as possible

  a. If the battery is depleted, the landing gear must be lowered using the emergency extension procedure. The gear position lights will be inoperative

If ammeter reading DOES begin to decrease within five minutes:

viii. Proceed with flight

ix. Ammeter: Monitor

8. Induction Icing

A. General
   i. As air is ingested through the engine intakes, the moisture can freeze inside the induction system, reducing or stopping the flow of combustible air to the engine
      a. Ice can also form on the exterior of the airplane, and clog the air intake openings
   ii. The Engine Roughness checklist is likely the most applicable checklist, especially if the onset of icing has not been noticed by the pilot
      a. This checklist will direct the pilot to open the alternate air source
   iii. Exit the icing – Run the checklist and attempt to exit the icing (climb/descent to better conditions, turn around, ATC vectors, etc.)

9. Door or Window Opening in Flight

A. POH Amplified Emergency Procedures
   i. The cabin door is double latched so the changes of it opening during flight are remote
      a. However, a partially open door will not affect the normal flight characteristics of the aircraft and a

normal landing can be made with the door open
    b. If both latches are open, the door will trail slightly open, and airspeed will be reduced slightly

B. Open Door Checklist
   i. To close the door in flight:
      a. Slow the aircraft to 87 KIAS
      b. Cabin Vents: Close
      c. Storm Window: Open
      d. If upper latch is open: Latch
      e. If side latch is open: Pull on armrest while moving latch handle to latched position
      f. If both latches are open: Latch side latch then top latch

C. In the event of an inadvertent door opening in flight or on takeoff, adhere to the following general information:
   i. Concentrate on flying the plane, an open door seldom compromises the ability of the plane to fly
   ii. Do not rush to land the plane if the door opens during lift off
      a. Climb to normal pattern altitude, fly a normal pattern, make a normal landing
   iii. Don't release the seatbelt to attempt to reach the door, leave the door alone, land, then close it
      a. The Piper Archer does have a checklist to close the door in flight. Do not lose control of the aircraft trying to close the door. Fly the plane first.
   iv. Most doors will not stay open, they will usually bang open then settle partially closed
      a. A slip toward the door may open it wider, and a slip away may push it closed

10. Inoperative or "Runaway" Trim

A. In case of Electric Trim Malfunction (if installed, and depending on the system installed)
   i. Trim Interrupt/AP Disconnect switch: Depress and hold throughout recovery
   ii. Trim Master switch: Off
   iii. Circuit Breaker: Pull
   iv. Trim Interrupt/AP Disconnect switch: Release
   v. Aircraft: Retrim manually
   vi. Leave system off until corrected

11. Flap Malfunction

A. General (no specific procedures in the Archer POH)
   i. Total Flap Failure
      a. This will necessitate a no flap approach and landing
         - This will require substantially more runway than normal (as much as 50% more)
         - The airplane must be flown in a relatively nose-high attitude as compared to flaps extended
            a This can make the runway difficult to see
         - A wider, longer pattern may be necessary to avoid diving to lose altitude and building up airspeed
         - The airplane will tend to float considerably during roundout
      b. If only flaps are unavailable, raise the approach airspeed 10 knots and maintain a flat approach angle
   ii. Asymmetric (Split) Flap
      a. A situation in which one flap deploys/retracts while the other remains in position
      b. The problem is indicated by a pronounced roll toward the wing with the least flap deflection
      c. Countering
         - Countered with opposite aileron
         - The yaw caused by the additional drag on the extended flap side will require opposite rudder
            a Aileron and opposite rudder results in a crossed control situation
         - Almost full aileron may be necessary at the reduced airspeed to maintain wings level
            a Therefore, do not attempt to land with a crosswind from the side of the deployed flap
               1. The additional roll control to counteract the crosswind may not be available

   d. Be aware of the differing stall speeds of each wing
      - The wing with the retracted flap will stall much earlier - possible crossed control stall condition
   e. Approach and landing should be flown at a higher-than-normal airspeed

12. Pressurization Malfunction

A. Not applicable for the Piper Arrow, but in general descend or use supplemental oxygen
   i. Hypoxia is the primary danger of decompression

Conclusion:

Brief review of the main points

Understanding different emergencies and how to deal with them is obviously important as you will always be prepared and be able to react quickly in the event one of these emergencies occurs.

XII.D. Emergency Equipment & Survival Gear

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner develops knowledge of emergency equipment and survival gear, understanding that certain equipment should be taken on certain flights to aid in survival and rescue operations. The learner will have knowledge in accordance with the ACS.
Key Elements	1. Equipment for the Situation 2. Equipment Care 3. Equipment Storage
Elements	1. Appropriate Equipment 2. Equipment Use and Care 3. Ballistic Parachute 4. Emergency Autoland Systems 5. Common Errors
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References 3. Basic Survival Kit
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner understands that flights over different terrain, and during different seasons require different emergency equipment and survival gear. The learner also knows that the gear must be properly cared for and stored to ensure it functions correctly upon use.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Would you want to crash land in the desert with a life raft, life preserver, warm clothes, and an average water supply as your survival equipment? Or wouldn't you rather have survival gear tailored to the flight you are taking? We want to be properly prepared for an emergency landing.

Overview

Review Objectives and Elements/Key ideas

What

Emergency equipment and survival gear refers to the equipment that should be carried onboard an airplane based on the flight being taken to aid in survival and rescue operations.

Why

By carrying and understanding flight tailored survival equipment you will greatly increase odds of survival & rescue.

How:

1. **Appropriate Equipment** AI.XII.D.K3
   A. For flight over uninhabited land areas, it is wise to take and know how to use survival equipment for the type of climate and terrain
      i. Basic plan is equipment and gear for 48-72 hours, adjust as required
   B. A survival kit should provide sustenance, shelter, medical care, and a means to summon help
      i. Consider the area and how long you may be stranded
   C. Consider the terrain, the climate/season, and type of emergency communication equipment needed
      i. Mountainous terrain in December requires different survival gear than coastal flying in August
      ii. Flying over the Midwest US poses different threats than a coastal flight
      iii. If a forced landing occurs at sea, chances for survival are governed by the degree of proficiency in emergency procedures and by the availability and effectiveness of water survival equipment
   D. General items to consider
      i. First Aid Kit & Field Medical Guide
      ii. Flashlight and batteries
      iii. Food and Water (water purification/filtration)
      iv. Tackle kit, Equipment to attain food
      v. Rope, paracord
      vi. Multi-tool or Knife, hatchet
      vi. Fire starter
      vii. Shelter, survival blanket
      viii. Signaling device(s), PLBs, GPS etc.
      ix. Maps & Compass
      x. Water/windproof layer
      xi. Sunscreen, bug spray
   E. More specific items should be considered based on the type of terrain and wildlife
      i. Climate Extremes AI.XII.D.K3a
         a. Cold
            - Warm clothes and layers, gloves, headgear, boots, snowshoes
            - Waterproof layer(s)
            - Blanket(s)
            - Shovel
            - Hand/body warmers
         b. Hot

        - Light clothing & hat (sun protection), sunglasses, sunscreen, extra water
    - ii. Mountainous Terrain AI.XII.D.K3b
        - a. Mosquito head net
        - b. Hiking boots
        - c. Warm/Cold weather clothing to adapt to temperature changes
        - d. Bear spray, or similar items depending on the wildlife
    - iii. Overwater AI.XII.D.K3c
        - a. Life vests, Dry suit/survival suit
        - b. Raft
- F. Think outside the box
    - i. What parts of the airplane/baggage could be used for survival?
        - a. Ex: The aircraft cover could be used for shelter, warmth, etc.

2. Equipment Use and Care

- A. Onboard emergency equipment can often consist of an ELT, a fire extinguisher, emergency axe, and the survival gear you have packed
- B. ELT AI.XII.D.K1
    - i. Purpose - transmit a downed aircraft's location for search and rescue personnel
        - a. Broadcast on emergency frequencies of 121.5 and 243.0 (no longer monitored by satellite) and 406 MHz on newer ELTs
    - ii. Operation/Use – If "armed" and when subject to crash-generated forces, ELTs are designed to automatically activate and continuously emit their respective signals, analog or digital
        - a. Transmitters will operate continuously for at least 48 hours over a wide temperature range
        - b. A properly installed, maintained, and functioning ELT can expedite search and rescue operations and save lives if it survives the crash and is activated (especially 406 MHz transponders)
        - c. Pilots/passengers should know how to activate the aircraft's ELT if manual activation is required
            - Be able to verify the ELT is functioning/transmitting an alert
    - iii. Servicing - Must be checked every 12 calendar months
        - a. FAR 91.207 – The battery must be replaced after 1-hour cumulative use or ½ its useful life
        - b. ELT Testing
            - Analog 121.5/243 MHz ELTs – Test only during the first 5 minutes after any hour
                - a If operational tests must be made outside of this period, they should be coordinated with the nearest FAA Control Tower
                - b Tests should be no longer than three audible sweeps
            - Digital 406 MHz ELTs – Test in accordance with the unit's manufacturer's instructions
            - Airborne tests are not permitted
    - iv. Storage – The ELT must be attached to the airplane in such a manner that the probability of damage to the transmitter in the case of a crash is minimized
        - a. Fixed/deployable automatic transmitters must be attached to the airplane as far aft as practical
- C. Fire Extinguisher AI.XII.D.K2
    - i. Purpose - Used to fight/extinguish fires
    - ii. Operation – Usually, pull the pin, point and squeeze the handle to spray
        - a. Adjust based on operating instructions
        - b. Aim at the base of the fire
    - iii. Servicing – Verify the extinguisher isn't expired, has been inspected, and contains the proper charge
    - iv. Storage – Ensure it is attached/secured where it is supposed to be, securely in its mount
        - a. The last thing you need is to have to find the fire extinguisher during a fire
- D. Emergency Axe
    - i. Purpose – To provide a means to exit in case the doors cannot be opened

- ii. Operation – If the door(s) cannot be opened, use the emergency axe to break through the canopy
  - a. In some aircraft, the axe can be used to cut through a portion of the fuselage
  - b. An axe is also a great addition to your survival gear
- iii. Servicing – Ensure the axe is onboard and properly mounted, and inspected as required
- iv. Storage – The axe should be stored in its mount as the manufacturer intends

E. RM: Survival Gear (for 48-72 hours) AI.XII.D.R1
- i. Purpose – Used for survival (food, water, shelter, warmth, etc.)
- ii. Operation/Use – The operation/use will vary by equipment. Use based on the instructions
- iii. Servicing – Verify the equipment is in good working order and does not need to be replaced, cleaned, etc.
  - a. Ensure electronic equipment is in good working order and properly charged/ready for use
  - b. Adjust the contents of the survival gear based on the trip, weather, terrain, etc.
- iv. Storage – Store the gear safely and accessibly on the airplane

3. Ballistic Parachute AI.XII.D.K4

A. Provides an alternative to certain emergency situations
- i. Parachute is deployed from the aircraft
- ii. Allows the airplane to descend slowly enough toward the ground such that occupants usually survive the impact with minor or no injuries
- iii. Understand and follow the procedures for arming/disarming and conditions under which it should be used

B. Conditions for Deployment
- i. Examples include:
  - a. Catastrophic loss of controllability due to a collision or mechanical failure
  - b. Pilot incapacitation
  - c. Loss of control
- ii. Airframe will be lost, but if deployed in an acceptable flight regime it can prevent injuries & save lives

C. Passenger Brief
- i. RM: Conditions for a safe deployment AI.XII.D.R2
  - a. When & How to deploy it
  - b. What to expect
- ii. Applicable hazards (Ex. Ground hazards with a deployed parachute, surface winds)
- iii. Evacuation procedures once on the ground

D. Instructor ACS Appendix 3 XII.D.
- i. Follow the manufacturer's procedures for arming/disarming the system before and after flight
- ii. Knowledge testing may include simulation and briefing of procedures but not actual deployment

4. Emergency Autoland (EAL) Systems AI.XII.D.K5

A. Designed to be deployed in the case of pilot incapacitation

B. How it Works
- i. Manually activated by a pilot or passenger
- ii. Automatic Activation
  - a. If the system sense erratic flying, it stabilizes the aircraft, and checks for pilot responsiveness
  - b. Without further input, it initiates an emergency descent
  - c. If no further input, it initiates the process for an automated landing
- iii. Transmits automated messages on the last selected frequency and Guard & squawks 7700
  - a. Call sign and intention to divert to a particular airport and runway

C. Passenger Brief
- i. RM: Conditions for a safe deployment AI.XII.D.R3
  - a. When & How to deploy it
  - b. What to expect
- ii. Evacuation procedures on the ground

    iii. Any applicable hazards
  D. FAA Safety Team Emergency Autoland Overview

5. **Common Errors** AI.XII.D.K6
   A. Failure to carry appropriate gear & equipment for the route of flight
   B. Failure to maintain the equipment/gear
   C. Lack of understanding of the operation and use of emergency gear & equipment
   D. Failure to understand when and how to deploy emergency systems (i.e., parachute & Autoland)

Conclusion:
Brief review of the main points
Emergency equipment should be tailored to the type of flight that will be taken. Gear should be stored and serviced properly to ensure it functions properly during an emergency. Survival manuals can be obtained to help in planning.

XII. RM Concepts

1. **Low Altitude Maneuvering**
    A. A small problem at high altitude can quickly become a big problem at a low altitude
        i. There is considerably less time to handle any issues at a low altitude
        ii. Avoid distractions, maintain situational awareness, and fly precisely
    B. Quick, panicked maneuvers, especially when slow, can result in a stall or loss of control close to the ground
        i. Especially important in engine failure emergencies
        ii. Be aware of, and avoid obstructions on and around the airfield
    C. Low Altitude Stall/Spin
        i. A low altitude stall or spin can leave little to no recovery time
            a. ALWAYS maintain coordination, and airspeed at low altitudes
            b. Keep airspeed in your crosscheck, especially at the lower speeds associated with takeoff and landing
            c. If you get any indication of a stall at low level, recover, `and climb to a safe altitude
        ii. Spin
            a. A spin is a result of a stall + yaw
            b. Prevention
                - Maintain coordination and don't use abrupt, excessive control inputs
                - Stop what you're doing and recover at the first sign of a stall
            c. Recovery (PARE)
                - Power - Idle
                - Ailerons - Neutral
                - Rudder - Full rudder opposite the spin direction
                - Elevator - Brisk, positive forward pressure (nose down)
                - Once the spin has stopped, neutralize the rudders and raise the nose, being careful not to stall again
            d. Different aircraft respond differently to spins and spin recoveries, follow the POH procedures
    D. CFIT (Controlled Flight into Terrain)
        i. AC 61-134: General Aviation CFIT Awareness
        ii. The solution to combating CFIT accidents starts on the ground
            a. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
            b. How the flight is planned and handled largely determines the safety of the flight
            c. Don't push the envelope during training – if there's a possibility of CFIT, go around and try again
        iii. Recommendations:
            a. Non-instrument rated VFR pilots should not attempt to fly in IMC
            b. Know and fly above minimum published safe altitudes
            c. If IFR, fly published procedures
            d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter
            e. Verify all ATC clearances. Question potentially hazardous clearances
            f. Maintain situational awareness both vertically and horizontally
            g. Comply with appropriate regulations for your specific operation
            h. Don't operate below minimum safe altitudes if uncertain of position or ATC clearance
            i. Be extra careful when operating in an area which you are not familiar
            j. Use current charts and all available information
            k. Use appropriate checklists
            l. Know your aircraft and equipment
2. **Collision Hazards**

A. Collision Avoidance
   i. Scanning
      a. Series of short, regularly spaced eye movements bringing successive areas into the central visual field
         - Each movement should not exceed 10º, each area should be observed for at least one second
      b. Divide attention between flying and scanning for aircraft
         - Applicable in all phases of flight, especially important in high traffic areas
   ii. Clearing Procedures
      a. Climb/Descent: Execute gentle banks to scan above/below the wings as well as other blind spots
      b. Prior to any turn: Clear in the direction of the turn
      c. Pre-Maneuver: Clearing turns – clear above/below, in front/behind
   iii. Operation Lights On
      a. Voluntary FAA safety program to enhance the see and avoid concept
      b. Turn on landing lights during takeoff and when operating below 10,000', day or night
         - Especially within 10 miles of an airport, in reduced visibility, where flocks of birds may be expected
   iv. Right-of-Way Rules (FAR 91.113)
      a. Pertinent to emergencies: An aircraft in distress has the right-of-way over all other traffic
         - Be cautious, other aircraft may not know you're in distress

B. Terrain
   i. Plan well and be aware of terrain that could cause a hazard
      a. Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
   ii. Day vs Night flying over terrain
      a. Be extra vigilant at night, when terrain may be impossible to see until it is too late
      b. A personal minimum may be to only fly over high terrain during daylight
   iii. Minimum Safe Altitudes (FAR 91.119)
      a. Anywhere: At an altitude allowing an emergency landing without undue hazard to persons or property
      b. Over Congested Areas: 1,000' above the highest obstacle within 2,000'
      c. Over other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

C. Obstacles and Wire Strike
   i. Antenna Towers
      a. Numerous antennas extend over 1,000'-2,000' AGL
         - Most are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as guy wires can extend 1,500' horizontally from a structure
   ii. Overhead Wires (may not be lighted)
      a. Overhead transmission wires and lines span runway departures and landmarks pilots frequently follow
         - Lakes, highways, railroad tracks, etc.

3. Distractions, SA & Disorientation, & Task Management

A. Distractions
   i. They're dangerous
      a. Can lead to slow speeds, unintended aircraft states, collisions, disorientation, missed radio calls, etc.
      b. Remove distractions from your field of view or, in the case of a person, explain the situation and ask them to stop what they are doing
   ii. Fly first! Aviate, Navigate, Communicate
      a. Focus flying and the emergency and tasks at hand - stay ahead of the aircraft
      b. Ensure checklists have been completed, and both you and the aircraft are prepared for what's next

B. Situational awareness (SA) & Disorientation
   i. Extremely important, lost SA has led to unsafe situations, mishaps, and incursions

- ii. Maintain SA
  - a. Starts with preflight planning
  - b. Know what's coming next and stay ahead of the airplane
  - c. Divide attention between inside and outside references
    - A step or two of the checklist, then eyes outside, and repeat
  - d. If SA is lost, admit it
    - If there's another pilot, let them take over while you catch up, if not, get the aircraft in a safe position (if landing, go around; if disoriented, trust the instruments and get to a safe attitude/altitude) and then solve the problem
- iii. High task load during an emergency can lead to a loss of SA
  - a. Emergency Descent: Maintain SA in relation to the level-off altitude, emergency & associated procedures, airplane configuration, and the plan (diversion)
- iv. Disorientation can be caused by, or lead to, an upset
  - a. Push: Apply forward pressure to unload the plane
  - b. Roll: Roll aggressively to the nearest horizon
  - c. Thrust: Adjust as required
  - d. Stabilize: Return to a safe flight condition

C. Task Management
- i. #1 Task: Safely flying the airplane
- ii. Divide attention between the aircraft, checklists, scanning, and communicating (ATC or CTAF)
  - a. No one responsibility should take your full attention full more than a short period
  - b. Accomplish emergency checklists and tasks but not at the expense of aircraft control
- iii. Understand what tasks need to be accomplished and when
  - a. Prioritize based on importance and time available
  - b. Checklists and standard operating procedures are extremely helpful and enhance safety
  - c. Organization is especially important in situations like this – many tasks, little time
- iv. Recognize when you are getting behind and find a way to catch up
  - a. If more time is needed, find somewhere to hold/circle, or slow down
  - b. Ask for assistance, if possible (ATC, another pilot, Guard, passengers, etc.)
  - c. "Attack the closest alligator" – Deal with the most pressing problem
- v. Proper task management can help prevent distractions, loss of SA, and disorientation
- vi. Safety is the number one priority – Aviate, Navigate, Communicate

POSTFLIGHT PROCEDURES

XIV.A. After Landing, Parking, & Securing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

Objectives	The learner should develop knowledge of postflight procedures and be able to perform them as required in the ACS.
Key Elements	1. Shutdown Checklist 2. Postflight Inspection 3. Securing the Airplane
Elements	1. Parking 2. Engine Shutdown 3. Deplaning passengers 4. Postflight Inspection 5. Securing the Aircraft 6. Common Error
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The learner can safely postflight the airplane based on different situations and at different airports.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Have you ever forgotten to turn something off after a flight? Leaving certain things running can be dangerous or costly. Properly securing an airplane isn't important just to save on costs though, weather, and other situations can cause damage and/or injuries.

Overview

Review Objectives and Elements/Key ideas

What

Postflight procedures are completed at the end of the flight when the airplane is parked, shut down, and properly secured.

Why

The postflight is just as important as preflight in maintaining the aircraft and keeping it in a safe condition for the next flight.

How:

1. **Parking**
    A. Select a parking location and heading that avoids the propeller/jet blast of other planes
        i. Also ensure you are not parked in a way that will blast other aircraft
        ii. Be considerate of others
    B. Whenever possible, park heading into the wind
        i. Often, your choice is limited to designated parking spots and tie downs - work with what you have
    C. Hand signals may be used if ramp personnel are available – be familiar
    D. After stopping, allow the airplane to roll forward to straighten the nosewheel

2. **Engine Shutdown** AI.XIV.A.K1
    A. Follow the procedures in the manufacturer's checklist for shutting down and securing
        i. Read each item aloud and perform the task
        ii. CE: Hazards resulting from failure to follow recommended procedures
            a. Like always, it is very important to follow the manufacturer's checklist
            b. Follow the published procedures to avoid missing important steps/creating an unsafe situation
    B. Set the parking brake to keep the plane from moving
    C. *Checklist:
        i. Throttle Idle
        ii. Fuel Pump Off
        iii. Avionics Master Off
        v. Mixture Idle Cut-Off
        vi. Magnetos Off
        vii. Master Switch Off

iv. Electrical Equipment Off

D. *While the engine is running, move the ignition switch from BOTH to OFF and back to BOTH
   i. This ensures the magnetos are properly grounded at every engine shutdown

E. Once the engine is shutdown, secure the flight deck
   i. Gather belongings and complete any securing checklist items (control lock, windows, shades, etc.)

F. *Double check that the master is off, the magnetos are off and the key has been removed, electrical equipment is off, the trim is neutral, flaps are up, and the mixture and throttle are idle

3. RM: **Deplaning Passengers** AI.XIV.A.R3

A. Ensure passengers understand the safe procedures for exiting the airplane (after engine shutdown)
   i. Inform them when it is safe to unbuckle and exit

B. Be aware of potential hazards nearby – other aircraft starting, taxiing in/out, etc.
   i. Ensure the passengers know where to go to prevent wandering into an unsafe situation

C. The aircraft should be shutdown/configured to allow for safe movement of passengers
   i. Chock to prevent movement

D. Do not let the passengers disembark until required checklists are complete and safety precautions met

4. Postflight Inspection AI.XIV.A.K1

A. Postflight Inspection
   i. Check the general condition of the aircraft
      a. Inspect the outside for any damage that may have occurred
      b. Look for leaks, streaks, stains
      c. Check oil, and other required fluids and replenish as necessary

B. Document all Discrepancies AI.XIV.A.K2
   i. Don't leave the problem for someone else
      a. Not only dangerous, but just rude
   ii. Allows maintenance to fix issues
   iii. If not fixed, informs the next pilot of the discrepancies
      a. They can make an informed go/no go decision
   iv. Can see trends/repeating problems

C. Fuel the Airplane
   i. If another flight is planned, the tanks should be filled based on that flight's fuel requirements
   ii. If the aircraft is going to be inactive, fill the tanks to prevent water condensation from forming
   iii. Refueling Procedures
      a. Ensure the ramp personnel use the proper type/grade of fuel
         - If possible, be there when the fueling takes place to ensure the proper grade
      b. Always check/drain the fuel prior to the next flight to be sure the proper fuel was used, and water/sediment hasn't accumulated since the last flight

5. Securing the Aircraft AI.XIV.A.K1

A. An essential part of every flight
   i. Remove personal belongings
   ii. Verify the nosewheel is straight
   iii. Tiedown/chocked
      a. Tie downs may vary significantly between chains and well-worn ropes
         - Chains are not flexible and therefore should not be made taught to prevent structural damage
         - Ropes are flexible and may be reasonably cinched to the tie down rings
      b. Brakes should be set based on local procedures – some request the brakes set, some don't
   iv. Flight controls secured, gust locks
   v. Covered (airframe, propeller, shades, inlet covers, pitot covers, etc.) and/or hangered
   vi. Windows closed

vii. Locked
viii. Any other requirements for your aircraft

B. RM: Airport Specific Security Procedures AI.XIV.A.R2
  i. Address any specific procedures (hours of operation, gates, codes, other requirements)

6. **CE: Poor planning, improper procedure, or faulty judgment in performance of postflight procedures**
  A. Be aware of the parking areas (ramps space, FBOs, etc.) at the destination
    i. If necessary, contact the FBO or parking management to verify the location and any procedures
  B. RM: Activities & Distractions AI.XIV.A.R1
    i. Taxiing and parking around buildings, people, etc. is no time to be distracted (sterile flight deck)
    ii. Follow all checklist(s) step by step, and ensure the airplane is left in a safe condition for the next flight
      a. Don't operate by memory
      b. If distracted, restart the checklist to ensure completion
    iii. Activities other than those associated with landing, parking & securing should be delayed
    iv. Do not skip the postflight inspection, assuming the next pilot will catch any issues in their preflight
      a. They might not catch the issue which could be very hazardous
      b. The issue could have been found and possibly fixed prior to them showing up (be considerate)
    v. If a discrepancy is noted, attempt to have the issue inspected/fixed prior to the next flight
      a. If unsure about something, ask (avoid faulty judgement)
        - Don't assume "it will be OK"
        - Don't make a safety decision for the next pilot – inform them and let them make the decision
        - Verify with the POH, an instructor, Chief Pilot, maintenance, etc.
    vi. Leaving the airplane in an unsafe place, condition, or situation can result in damage and/or injuries

Common Errors: AI.XIV.A.K3
- Hazards resulting from failure to follow recommended procedures
- Poor planning, improper procedure, or faulty judgment in performance of postflight procedures

Conclusion:
Brief review of the main points
When parking and shutting down the airplane it is very important to follow the manufacturer's established guidelines to ensure everything is properly shut down and secured.

APPENDIX

A. Flight Review

References: Currency Requirements and Guidance for the Flight Review and Instrument Proficiency Check (AC 61-98), FAR 61.56 – Flight Review, Certificate: Pilots and Flight and Ground Instructors (AC 61-65), WINGS – Pilot Proficiency Programs (AC 61-91)

1. **Purpose**
   A. A routine evaluation of a pilot's ability to conduct safe flight
   B. Not a test or checkride, rather a training event in which proficiency is evaluated
2. **Role of the Instructor**
   A. Provide an evaluation, however instruction is also encouraged (they should leave a better pilot)
   B. As long as deficiencies are corrected, providing instruction does not prevent a successful review
3. **FAR 61.56**
   A. Flight Review Requirements – Minimum of 1 hour ground and 1 hour flight training, covering:
      i. Current operating/flight rules (part 61/91)
      ii. Maneuvers/procedures that, at the discretion of the CFI, demonstrate safe operation
   B. Aircraft –Must be accomplished in an aircraft for which the pilot (and CFI) is rated (FAR 61.56(c)(1))
      i. If a pilot holds multiple ratings, a flight review in any one counts for all
   C. Exceptions to the Flight Review:
      i. 61.56(d) – Passed a proficiency check, or practical test in the last 24 months
      ii. 61.56(e) – Completed one or more phases of WINGS in the last 24 months (more info: AC 61-91)
      iii. 61.56(f) – CFI who has completed a renewal of a flight certificate in the last 24 months (61.197)
4. **Planning the Flight Review**
   A. Tailor the Review to the Pilot's Needs (talk to the pilot to create a plan)
      i. Type of aircraft, and type of flying usually done by the pilot
      ii. Amount and recency of flight experience
      iii. Specific topics/weaknesses they would like to focus on or review
   B. AC 61-98 Focus Areas
      i. Pilot Deviation Avoidance
         a. Review airspace types/ground operating procedures/best practices to avoid deviations
      ii. Automation Competency
         a. Numerous accidents/incidents have been attributed to a lack of proficiency in automation
      iii. AOA Systems (Safety initiative aimed at reducing the GA accident rate/loss of control accidents)
         a. If equipped with AOA indicator, evaluate proper use. If not, review AOA aerodynamic principles
   C. Build the Plan Based on the Individual - See sample Topics/Maneuvers below
   D. Agreement on the review
      i. Review the plan with the pilot to reach an understanding of how the flight review will be conducted
      ii. Review the criteria for satisfactory completion of the flight review (ex. ACS/PTS standards)
5. **Post Flight Review**
   A. Debrief the pilot
      i. Satisfactory or not, provide a comprehensive analysis of performance, including ways to improve
   B. If unsatisfactory, log the flight as dual instruction given, not as a failure (not a checkride)
      i. Offer a practical course of action to regain proficiency
6. **Endorsement**
   A. AC 61-65: I certify that [First name, MI, Last Name], [grade of pilot certificate], [certificate number], has satisfactorily completed a flight review of § 61.56(a) on [date].

A. Flight Review

Ground Review Topics (AC 61-98)

Pilot

- Experience
  - Recent Flight Experience (61.57)
- Responsibility
  - Authority (91.3)
  - ATC Instructions (91.123)
  - Preflight Action (91.103)
  - Safety Belts (91.107)
  - Flight Crew at Station (91.105)
- Cautions
  - Careless or Reckless Operation (91.13)
  - Dropping Objects (91.15)
  - Alcohol or Drugs (91.17)
  - Supplemental Oxygen (91.211)
  - Fitness for Flight (AIM 8-1)

Aircraft

- Airworthiness
  - Basic (91.7)
  - Flight Manual, Markings, Placards (91.9)
  - Certification Required (91.203)
  - Instruments/Equipment Requirements (91.205)
    - ELT (91.207)
    - Aircraft Lights (91.209)
    - Transponder Requirements (91.215)
    - Inoperative Instrument/Equip (91.213)
- Maintenance
  - Responsibility (91.403)
  - Maintenance Required (91.405)
  - Maintenance Records (91.417)
  - Operation after Maintenance (91.407)
- Inspections
  - Annual, ADs, 100-hour (91.409)
  - Altimeter & Pitot Static (91.411)
  - VOR Check (91.171)
  - Transponder (91.413)
  - ELT (91.207)

Environment

- Airports
  - Markings (AIM 2-3)
  - Operations (AIM 4-3, 91.125, 91.126)
  - Traffic Patterns (91.126)
- Airspace
  - Altimeter Settings (91.121, AIM 7-2)
  - Min Safe Alts (91.119, 91.177)
  - Cruising Alts (91.159, 91.179, AIM 3-1-5)
  - Speed Limits (91.117)
  - Right-of-Way (91.113)
  - Formation (91.111)
  - Cntrld Airspace (AIM 3-2, 91.129, 130, 131, 135)
  - Class G (Aim 3-3)
  - Special Use (AIM 3-4, 91.133, 137, 141, 143, 145)
  - Emergency Rules (91.139, AIM 5-6)
- ATC
  - Services (AIM 4-1)
  - Radio Comms (AIM 4-2, Pilot Controller Glossary)
  - Clearances (AIM 4-4)
  - Procedures (AIM 5)
- Weather
  - Meteorology (AIM 7-1)
  - Wake Turbulence (AIM 7-4)

Flight Activities (AC 61-98)

- Preflight Preparation
  - Weather Information
  - Cross-Country Flight Planning
  - Performance and Limitations
  - Operation of Systems
- Preflight Procedures
  - Inspection(s)
  - Flight deck Management
  - Before Takeoff Check
- Airport Operations
  - Radio Communications
  - Airport, Runway, Taxiway Signs/Markings/Lights
- Takeoffs, Landings, Go-Arounds
  - Normal/Crosswind Takeoff/Climb and Landing*
  - Soft Field Takeoff/Climb and Landing
  - Short Field Takeoff/Climb and Approach
  - Go-Around / Rejected Landing*
- Performance Maneuvers
  - Steep Turns
- Navigation
  - Pilotage / Dead Reckoning
  - Nav Systems and Radar Services
  - Diversion
  - Lost Procedures
- Slow Flight and Stalls*
  - Slow Flight
  - Power Off Stalls
  - Power On Stalls
  - Spin Awareness
- Basic Instrument Maneuvers
  - Straight and Level / Turns to Headings*
  - Recovery from Unusual Attitudes*
  - Radio Comm/Navigation Systems
- Emergency Operations
  - Emergency Approach and Landing
  - Systems and Equipment Malfunctions
  - Automation Failure
- Postflight Procedures
  - After Landing, Parking, and Securing

NOTES

Possible Structure: Out-and-back. One leg focuses on XC procedures, and one leg focuses on air work. Remember, some ground review can be gauged and/or accomplished in flight.

Structure activities and review based on pilot's normal flying. For example, a different plan for someone who flies local/single airport flights vs long-distance XCs in busy terminal areas.

*Maneuvers critical to flight – recommended to be reviewed

B. Plan of Action

The intent is to use time and altitude as efficiently as possible during your student's training flights. Below are two sample plans designed to conserve energy and minimize drone time while incorporating all maneuvers. The instructor should tailor the individual plan based on airfield, airspace, maneuver and training requirements, etc.

HIGH TO LOW

PRIVATE PILOT

"High" Alt

1. **SLOW FLIGHT & STALLS**
   - Maneuvering during Slow Flight
   - Power-Off Stalls
   - Power-On Stalls
2. **PERFORMANCE MANEUVER**
   - Steep Turns
3. **BAI FLIGHT**
   - Straight-and-Level
   - Constant Airspeed Descent
   - Constant Airspeed Climb
   - Turns to Heading
   - Unusual Attitudes

Descent

4. **EMERGENCY OPERATIONS**
   - Systems & Equipment Malfunctions
   - Emergency Approach / Go-Around

Low Alt

5. **GROUND REFERENCE MANEUVERS**
   - Rectangular Course
   - S-Turns
   - Turns Around a Point
6. **TAKEOFFS & LANDINGS**
   - Normal / Crosswind
   - Soft-Field
   - Short-Field
   - Slip to a Landing
   - Go-Around

COMMERCIAL PILOT

Climb

1. **PERFORMANCE MANEUVER**
   - Chandelles (Up to altitude)

"High" Alt

2. **SLOW FLIGHT & STALLS**
   - Maneuvering During Slow Flight
   - Power-On Stalls
   - Power-Off Stalls
3. **PERFORMANCE MANEUVERS (CONT)**
   - Steep Turns
   - Lazy Eights

Descent

4. **EMERGENCY OPERATIONS**
   - Systems & Equipment Malfunctions
   - Steep Spiral / Emergency Approach

Low Alt

5. **GROUND REFERENCE MANEUVERS**
   - Eights on Pylons
6. **TAKEOFFS & LANDINGS**
   - Normal / Crosswind
   - Soft-Field
   - Short-Field
   - Power-Off 180
   - Go-Around

The student climbs to training altitude, transitions from the climb into slow flight and stalls, completes the maneuvers, and attitude instrument flight (if applicable), and then uses a simulated engine failure to descend to ground reference maneuver altitudes before returning to the airfield for landings.

LOW TO HIGH

PRIVATE PILOT

Low Alt

1. **TAKEOFFS & LANDINGS**
   - Normal / Crosswind
   - Soft-Field
   - Short-Field
   - Slip to a Landing
   - Go-Around
2. **GROUND REFERENCE MANEUVERS**
   - Rectangular Course*
   - S-Turns
   - Turns Around a Point

Climb

3. **BAI FLIGHT**
   - Straight-and-Level
   - Constant Airspeed Climb
   - Constant Airspeed Descent
   - Turns to Heading
   - Unusual Attitudes

"High" Alt

4. **SLOW FLIGHT & STALLS**
   - Maneuvering during Slow Flight
   - Power-Off Stalls
   - Power-On Stalls
5. **PERFORMANCE MANEUVER**
   - Steep Turns

Descent

6. **EMERGENCY OPERATIONS**
   - Systems & Equipment Malfunctions
   - Emergency Approach & Landing

COMMERCIAL PILOT

Low Alt

1. **TAKEOFFS & LANDINGS**
   - Normal / Crosswind
   - Soft-Field
   - Short-Field
   - Power-Off 180
   - Go-Around
2. **GROUND REFERENCE MANEUVERS**
   - Eights on Pylons

Climb

3. **PERFORMANCE MANEUVERS**
   - Chandelles (Up to altitude)

"High" Alt

4. **SLOW FLIGHT & STALLS**
   - Maneuvering During Slow Flight
   - Power-On Stalls
   - Power-Off Stalls
5. **PERFORMANCE MANEUVERS (CONT)**
   - Steep Turns
   - Lazy Eights

Descent

6. **EMERGENCY OPERATIONS**
   - Systems & Equipment Malfunctions
   - Steep Spiral / Power-Off 180

The student begins in the pattern, and transitions to the applicable ground reference maneuvers. BAI or Chandelles can be accomplished during the climb to an altitude where slow flight, stalls, and maneuvers can be practiced. Finally, a simulated engine failure descends back to the airfield.

*Rectangular course doesn't make a lot of sense after patterns

C. Common Carriage

References:

- FAA Order 8900.1. Volume 2, Chapter 2, Section 2
- CFR 61.133
- AC 120-12A: Private vs Common Carriage
- NBAA Certification of Commercial Aircraft Operations – Which Rules Apply?

This is a basic overview of common vs private carriage, certificates, and the like. For considerably more detail, use the reference links above, and additional information here:

- How to Become a Certificated Air Carrier
- FAR Part 119 – Certification: Air Carriers and Commercial Operators

1. **FAR 61.133: Privileges and Limitations**
    A. Privileges – A person holding a commercial pilot certificate may act as PIC of an aircraft:
        i. Carrying persons or property for compensation or hire
        ii. For compensation or hire
        iii. In both cases, the pilot must be qualified for the type of operation
    B. Limitations
        i. Commercial certificate without an instrument rating in the same category and class
            a. Carriage of passengers for hire on cross-country flights in excess of 50 nautical miles at night is prohibited
                - Limitations is lifted with an instrument rating in the same category and class
    C. These privileges allow the pilot to act as PIC – i.e., someone can hire you to fly their plane
        i. Commercial certificate does not allow you to operate as an air carrier or commercial operator
    D. The type of operation you're hired to fly for will dictate the applicable FARs and governing regulations that they (and therefore you, as the pilot) operate under
        i. The operation has to decide whether they fall under common carriage or private carriage and drill down from there
            a. Also applies if you'd like to start you own business as an air carrier or commercial operator
2. **What is Common Carriage & Private Carriage?**
    A. Common Carriage and Private Carriage are common law terms
        i. The Federal Aviation Act of 1958 uses the term "common carriage" but does not define it
        ii. AC 120-12 provides guidelines to define common carriage and its opposite, private carriage
    B. Common Carriage
        i. A carrier becomes a common carrier when it "holds itself out" to the public (or a segment of the public) as willing to provide transportation to any person who wants it
        ii. Holding Out
            a. Makes a person a common carrier
            b. Can be done in many ways, does not matter how it's done
            c. Examples
                - Signs and advertising are most direct means of holding out
                - Actions of agents or salesman who obtain passengers from the general public
                - A reputation to serve all (even without advertising)
        iii. 4 elements defining a common carrier
            a. A holding out of a willingness to

        b. Transport persons or property
        c. From place to place
        d. For compensation
    iv. As a pilot with a commercial certificate, you cannot "hold out"
        a. Illegal without the proper Part 119 certificates (more below)
  C. Private Carriage
        a. Carriage for hire which does not involve "holding out"
        b. Carriage for one or several select customers, generally on a long-term basis
            - Too many contracts = willingness to make a contract with anybody (common carriage)

3. **Governing Regulations**
    A. Once you've decided whether the operation falls under common carriage or private carriage, the next step is to decide what FAR regulations it falls under
    B. Common carriage operations are required to be conducted under FAR Part 121, or Part 135 (depending on the type of aircraft, seating configuration, and payload capacity)
        i. An operational certificate is required (issued under Part 119)
        ii. Two basic types of Air Operator Certificates:
            a. Air Carrier Certificate: Issued for interstate, foreign, or overseas transportation, or to carry mail
            b. Operating Certificate: Intrastate common carriage operations
    C. Private carriage, on the other hand, is conducted under Part 125, Part 135 (again, depending on the type of aircraft, seating configuration, and payload capacity), or Part 91 Subpart D
        i. Most private carriage also requires an operating certificate (exceptions for Part 91)
    D. If they both require operating certificates, then what's the difference?
        i. Regulations and limitations
        ii. Generally, private carriage is less regulated than common carriage
            a. Ex. Part 121 pilots rest rules
4. **Kind of Operation**
    A. Note: this is getting into extra, possible overly confusing information. Unless the learner is considering starting their own operation it may not be necessary
    B. The final step is to decide the kind of operation
        i. Part 121
            a. Domestic: Between two points inside the contiguous 48 states
            b. Flag: Between a point outside of contiguous 48 states to a point inside the contiguous 48
            c. Supplemental: Cargo, charter, departure location/times are negotiated with customer (vs scheduled)
        ii. Part 135
            a. Commuter: Scheduled time and locations with at least 5 round trip flights per week
            b. On-demand: Departure time and location and arrival location are negotiated with the customer
    C. FAA Order 8900.1. Volume 2, Chapter 2, Section 2
        i. Table 2-4 looks at the Operating Certificate, Seating/Payload, 14 CFR Operating Part, & Kind of Op.
5. **FAR 119.1(e) Exceptions**
    A. Operations for compensation or hire that do not require an air carrier or commercial operator certificate
        i. Student instruction
        ii. Nonstop commercial air tours (a lot more detail to this in the FAR)
        iii. Ferry or training flight
        iv. Aerial work (crop dusting, seeding, spraying, banner towering, aerial photography, and more)
        v. Parachute operations within 25 statute miles of the airport
        vi. Part 375 operations (foreign civil aircraft in the US)
        vii. Emergency mail service
        viii. Operations under part 91.321 (carriage of candidates in elections)

6. Confused?

A. Discuss any proposed operation with the FAA
   i. Early discussions can prevent a lot of pitfalls and potential illegal operations

B. As a commercial pilot you can be hired to fly for an operation but, other than the FAR 119.1(e) exceptions, you cannot hold out or offer your services without the proper FAA/FAR approval and certificates

D. ADM, CRM & SRM

References: Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

Objectives	The learner understands the importance of ADM, CRM, and risk management and can apply the concepts to future flights.
Elements	1. Aeronautical Decision Making 2. Hazardous Attitudes 3. Stress 4. Risk Assessment & Management 5. SRM & CRM 6. Decision Making Process 7. Evaluation
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	4. Participate in discussion 5. Take notes 6. Ask and respond to questions
Completion Standards	The learner can apply CRM, ADM, and risk management concepts to future flights.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Overview

Review Objectives and Elements/Key ideas

What

A systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances

Why

Despite all the changes in technology to improve flight safety, one factor remains the same: the human factor which leads to errors.

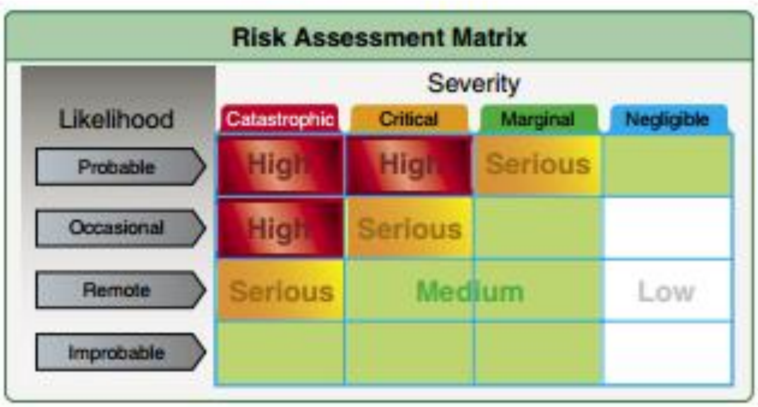
How:

1. **Aeronautical Decision Making (ADM)**
   - A. A systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances
   - B. Teaching pilots to make sound decisions is the key to preventing accidents
     - i. It is estimated that approximately 80% of all aviation accidents are a result of human factors
   - C. Steps for Good Decision Making
     - i. Identify personal attitudes hazardous to safety & learn behavior modification techniques
     - ii. Learn how to recognize and cope with stress
     - iii. Develop risk assessment skills
     - iv. Use all resources
     - v. Evaluate effectiveness of one's ADM skills
2. **Risk Assessment & Management**
   - A. 4 Fundamental Principles of Risk Management
     - i. Goal of these principles is to proactively identify safety-related hazards and mitigate associated risks
     - ii. Accept no Unnecessary Risk
       - a. Only accept the necessary risk
         - Flying is impossible without risk, do not make a situation more dangerous than necessary
     - iii. Make Risk Decisions at the Appropriate Level
       - a. In single pilot situations, the pilot makes decisions (not ATC, or passengers)
       - b. In other situations, it may be beneficial to "go up the ladder" for a decision
         - i.e., Talk to the chief pilot or experienced CFI about a potentially risky situation
     - iv. Accept Risk When Benefits Outweigh the Costs
       - a. Analyze costs and benefits, make an informed decision
     - v. Integrate Risk Management into Planning at All Levels
       - a. Safety requires risk management planning in all stages of flight
         - Plan early and throughout to avoid unnecessary, amplified risk
   - B. Risk Management Process
     - i. Step 1: Identify the Hazard

        a. A hazard is any real or potential condition that can cause degradation, injury, illness, death, damage to or loss of equipment or property
    ii. Step 2: Assess the Risk
        a. Determine the level of risk associated with the identified hazards
            - Assess in terms of its likelihood (probability) and its severity (consequences)
        b. Develop a method to tangibly measure risk (Risk Assessment Matrix, below)
    iii. Step 3: Mitigate the Risk
        a. Look into ways to reduce, mitigate, or eliminate the risk
        b. All risks have 2 components: Probability of occurrence & Severity of the hazard
            - Try to reduce or eliminate at least one component
        c. Use the Cost/Benefit analysis to decide if it is worth accepting the risk

C. Level of Risk
    i. The level of risk posed by a given hazard is measured in terms of:
        a. Severity (extent of possible loss)
        b. Probability (likelihood that a hazard will cause a loss)

D. Assessing Risk
    i. Pilots must differentiate *in advance* between a low risk flight and a high-risk flight
    ii. Establish a review process and develop strategies to minimize risk on the high and low risk flights
    iii. The Risk Matrix is a helpful risk assessment model
        a. Assesses the likelihood of an event occurring and the consequences of that event
            - Likelihood (probability of occurrence): Probable, Occasional, Remote, Improbable
                a i.e., Likelihood of a pilot flying MVFR to encounter IFR conditions
            - Severity: Catastrophic, Critical, Marginal, Negligible
                a i.e., How severe the consequences could be if the pilot is not IFR rated
        b. High Probability/Severity is bad and vice versa:



E. Mitigating Risk
    i. After determining the level of risk, the pilot needs to reduce the risk
        a. Analyze options that can reduce unnecessary risk
            - i.e., Cancel/delay flight, bring CFI or more experienced pilot, etc.
    ii. By effectively mitigating known risks to acceptable levels, pilots can complete their flights safely or ensure alternate options are selected for the occasions when the flight cannot be accomplished

F. PAVE Checklist
    i. Another way to mitigate risk
    ii. The risks of flight are divided into 4 categories
        a. Once the risks have been identified, decide whether the risk or combination or risks can be managed safely and successfully. If not, the flight should be cancelled

iii. **P**ilot in Command: Am I ready? (IMSAFE Checklist, proficiency, recency, currency, etc.)
iv. **A**ircraft: Is the aircraft appropriate for the trip?
    a. Maintenance, Landing Distance, Performance Capabilities, Equipment, Fuel load, Altitude, etc.
v. En**V**ironment: Weather, Terrain, Airports, Airspace, Day/Night, etc.
vi. **E**xternal Pressures: Influences outside of the flight that create pressure to complete the flight, often at the expense of safety
    a. This is the most important key to risk management because it is the one risk factor category that can cause a pilot to ignore all the other risk factors
    b. Follow your own personal operating procedures (don't bend the rules for anyone), plan for delays, and manage passenger's expectations to reduce external pressure

3. **Single Pilot Resource Management / Crew Resource Management** (Use all Resources)
   A. What is it?
      i. How to gather information, analyze it, and make decisions
      ii. Application of team management concepts in the flight deck environment
         a. Includes all groups routinely working with the flight crew who are involved in decisions required to operate a flight safely
            - Pilots, dispatchers, cabin crew, maintenance, ATC
      iii. Pilots of small and large aircraft must make effective us of all available resources
   B. Use of Resources
      i. Use all available resources,
         a. Think outside the box
      ii. Internal Resources
         a. Found in the flight deck during flight
            - Equipment, systems, charts, books, etc.
            - Ingenuity, knowledge, and skill
            - Other passengers (even if they are not pilots)
      iii. External Resources
         a. ATC and flight service specialists
            - Traffic advisories, vectors, weather info, emergency assistance
      iv. Workload Management
         a. Plan, prioritize, and sequence to prevent overload
         b. Prepare for high workload situations
            - Don't wait until you're in the situation
            - i.e., prepare for the approach before it begins
         c. Be able to recognize high workloads
            - Faster paced work along with divided attention
            - Stay ahead as much as possible to prevent high workloads
            - Manage tasks in order of importance when behind
   C. 5 P's Check
      i. Used to evaluate the pilot's current situation at key decision points during the flight, or when an emergency arises
         a. This is a very helpful portion of Single Pilot Resource Management (SRM)
         b. Based on the idea that the pilot has five variables that impact the environment and can cause the pilot to make a single critical decision, or several less critical decisions, that when added together can create a critical outcome
         c. The process is simple; at least 5 times before/during the flight, review and consider the 5 P's and make the appropriate decision required by the current situation

- The decision points include preflight, pre-takeoff, hourly or at the midpoint of flight, pre-descent, and just prior to the final approach fix or entering the traffic pattern

ii. The 5 P's:

a. The Plan
- The mission. It contains planning, weather, route, fuel, publication currency, etc.
- The plan is always changing (weather changes, delays, restrictions, etc.), adjust with it

b. The Plane
- Condition, abilities (performance, but also automation, database currency, etc.), equipment, systems, etc.

c. The Pilot
- IMSAFE
- Allows the pilot to recognize and review his/her physiological situation

d. The Passengers
- Passenger's desires can have an influence on decision making and risk management
  - a Plan as much as possible
- Ensure passengers are involved in decision making process
  - a Ensure they understand risk involved in situations
    1. i.e., IFR approach below minimums or takeoff with IFR below landing minimums
- Understand what passengers want to do
  - a They may be more risk averse than you

e. The Programming
- Plan when and where programming approaches/route changes, and airport information gathering should be accomplished, as well as when it should not be accomplished
- Pilot familiarity with the equipment, the route, the local air traffic control environment, and personal capabilities should drive when, where, how the automation is programmed and used
- Always consider pilot capabilities in relation to programming

4. Decision Making Process

A. DECIDE Model (pictured below)

i. Detect, Estimate, Choose, Identify, Do, Evaluate

B. Analytical Models

i. Examples include DECIDE model and 5 Ps

ii. Good decisions result when pilots gather all information, review it, analyze the options, rate the options, select a course of action, and evaluate the course of action for correctness

a. This level of analysis is not always possible

C. Automatic or Naturalized Decision Making

i. Reflexive type of decision making anchored in training and experience

ii. In an emergency, a pilot may not survive if they apply analytical models to every decision

iii. Automatic or Naturalized Process

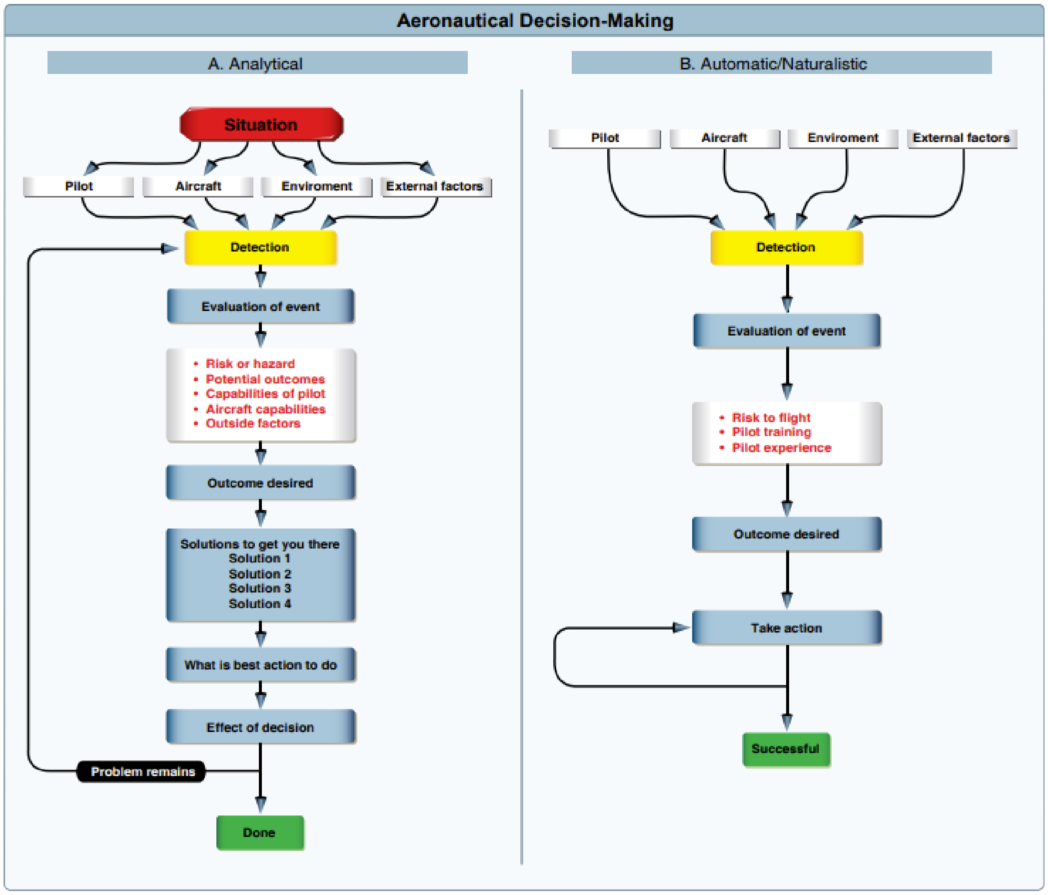
a. Experts faced with a task loaded with uncertainty first assess if the situation looks familiar

b. Rather than comparing pros and cons of different approaches (analytical model), they imagine how one or a few courses of action will play out and take the first workable option they find

c. May not be the best of all possible choices, but it often works remarkably well

iv. Experienced based actions trigger response to specific situations

v. Improves with training and experience



The DECIDE model

1. **Detect.** The decision maker detects the fact that change has occurred.
2. **Estimate.** The decision maker estimates the need to counter or react to the change.
3. **Choose.** The decision maker chooses a desirable outcome (in terms of success) for the flight.
4 **Identify.** The decision maker identifies actions which could successfully control the change.
5. **Do.** The decision maker takes the necessary action.
6. **Evaluate.** The decision maker evaluates the effect(s) of his/her action countering the change.

Figure 2-14. *The DECIDE model has been recognized worldwide. Its application is illustrated in column A while automatic/naturalistic decision-making is shown in column B.*

vi. Operational Pitfalls (pictured below)
   a. Pitfalls/behavioral traps also come with experience
      - As a rule, more experienced pilots try to complete flights as planned, please passengers, meet schedules
      - Can have an adverse effect on safety and contribute to unrealistic assessment of skills
      - Tendencies must be eliminated

5. Evaluation

A. Review and debrief each flight
   i. What went well?
   ii. What could have gone better?
   iii. What will I (or we) do next time?

B. Areas to Consider in the Evaluation
   i. Planning & Decision Making
   ii. Leadership Effectiveness

iii. Situational Awareness
iv. Communication
v. Monitor/Cross-Check
vi. Workload Management
vii. Automation Management

Conclusion:
Brief review of the main points

Operational Pitfalls	
Peer pressure	Poor decision-making may be based upon an emotional response to peers, rather than evaluating a situation objectively.
Mindset	A pilot displays mind set through an inability to recognize and cope with changes in a given situation.
Get-there-itis	This disposition impairs pilot judgment through a fixation on the original goal or destination, combined with a disregard for any alternative course of action.
Duck-under syndrome	A pilot may be tempted to make it into an airport by descending below minimums during an approach. There may be a belief that there is a built-in margin of error in every approach procedure, or a pilot may want to admit that the landing cannot be completed and a missed approach must be initiated.
Scud running	This occurs when a pilot tries to maintain visual contact with the terrain at low altitudes while instrument conditions exist.
Continuing visual flight rules (VFR) into instrument conditions	Spatial disorientation or collision with ground/obstacles may occur when a pilot continues VFR into instrument conditions. This can be even more dangerous if the pilot is not instrument rated or current.
Getting behind the aircraft	This pitfall can be caused by allowing events or the situation to control pilot actions. A constant state of surprise at what happens next may be exhibited when the pilot is getting behind the aircraft.
Loss of positional or situational awareness	In extreme cases, when a pilot gets behind the aircraft, a loss of positional or situational awareness may result. The pilot may not know the aircraft's geographical location or may be unable to recognize deteriorating circumstances.
Operating without adequate fuel reserves	Ignoring minimum fuel reserve requirements is generally the result of overconfidence, lack of flight planning, or disregarding applicable regulations.
Descent below the minimum en route altitude	The duck-under syndrome, as mentioned above, can also occur during the en route portion of an IFR flight.
Flying outside the envelope	The assumed high performance capability of a particular aircraft may cause a mistaken belief that it can meet the demands imposed by a pilot's overestimated flying skills.
Neglect of flight planning, preflight inspections, and checklists	A pilot may rely on short- and long-term memory, regular flying skills, and familiar routes instead of established procedures and published checklists. This can be particularly true of experienced pilots.