ACS REVIEW

PRIVATE

THE BACKSEAT PILOT

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* - The lessons are generally based off the DA20. DA20 specific information is denoted with an *.
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CONTACT

If you come across any errors, or have any questions please contact us at Info@thebackseatpilot.com, or head to our website and send us a contact form (they both go to the same inbox).

RECENT UPDATES

Most recent updates are indicated with a Red bar in the left margin

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DATE	LESSON	UPDATE
May 2021	I.C. Weather Information	Reorganized/Updated - Primarily Aviation Weather section
January 2020	I.D. Cross Country Flight Planning	Altitudes flown based on Mag Course
June 2018	June 11 2018 ACS Revision	Various updates to the majority of the Tasks

Contents

PREFLIGHT PREPARATION

I.A. Pilot Qualifications

References: 14 CFR Parts 1, 68, 91, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Requirements for Certification, Recent Flight Experience, and Record Keeping**
    A. Requirements for Certification
        i. FAR 61.103 – Private Pilot Eligibility Requirements
            a. Be at least 17 years of age
            b. Be able to read, speak, write and understand the English language
            c. Receive a logbook endorsement from:
                - An authorized instructor who conducted training on (or reviewed home study on) the aeronautical knowledge areas (FAR 61.105b) that apply to the rating sought,
                - and certified that person is prepared for the required practical test
            d. Meet the aeronautical experience requirements (FAR 61.109)
            e. Pass a practical test (areas of operation listed in 61.107b)
            f. Hold a US student pilot certificate, sport pilot certificate, or recreational pilot certificate
    B. Requirements for Recent Flight Experience
        i. Pilot in Command (FAR 61.57)
            a. To carry passengers - day
                - 3 takeoffs and landings within the preceding 90 days as the sole manipulator of the flight controls in the same category, class, and type (if required)
                    a Tailwheel landings must be to a full stop
            b. To carry passengers - 1 hour after sunset to 1 hour before sunrise
                - 3 takeoffs and landings to a full stop from 1 hour after sunset to 1 hour before sunset within the preceding 90 days to a full stop as the sole manipulator of the flight controls in the same category, class, and type (if required)
        ii. Flight Reviews (FAR 61.56)
            a. No person may act as PIC unless, within the preceding 24 calendar months he/she has accomplished a flight review and received a log book endorsement certifying it was completed
            b. Flight review must be given by an authorized instructor
            c. Consists of a minimum of 1 hour of flight training and 1 hour of ground training and must include:
                - A review of the current general operating rules and flight rules of Part 91 and a review of those maneuvers and procedures necessary to demonstrate the safe exercise of the certificate
            d. A flight review is not necessary, if in the past 24 calendar months, the pilot has passed any of the following:
                - A pilot proficiency check or practical test for a pilot certificate, rating, or operating privilege
                - A practical test for the issuance of a flight instructor certificate, and additional rating on a flight instructor certificate, renewal of a flight instructor certificate, or reinstatement of a flight instructor certificate
                - If one or more phase of an FAA sponsored pilot proficiency award program has been accomplished a flight review is not required

- A student pilot undergoing training for a certificate and has a current solo flight endorsement does not need a flight review

e. A flight review may be accomplished in combination with the PIC currency requirements mentioned above (3 T/O & LDG) and in FAR 61.57

C. Requirements for Record Keeping (FAR 61.51)

i. Training time and Aeronautical Experience - Document and Record:

a. Training and aeronautical experience used to meet the requirements for a certificate, rating, or flight review

- A person may log training time when that person receives training from an authorized instructor in an aircraft, flight simulator, or flight training device.
- The training time must be logged in a logbook and must:
  - a Be endorsed in a legible manner by the authorized instructor; and
  - b Include a description of the training given, the length of the training lesson, and the authorized instructor's signature, certificate number, and certificate expiration date

b. The aeronautical experience required for meeting the recent flight experience requirements

ii. Logbook Entries (FAR 61.51) - For the purpose of record keeping, the following information must be entered in the logbook:

a. General

- Date
- Total flight time or lesson time
- Departure and arrival location
  - a For a simulator, just the location where the lesson occurred
- Type and identification of aircraft, flight simulator, flight training device, or aviation training device
- The name of a safety pilot, if required

b. Type of Training

- Solo
  - a A pilot may log as solo flight time only that flight time when the pilot is the sole occupant of the aircraft
- PIC
  - a A pilot may log PIC time
    1. When the pilot is the sole manipulator of the controls of an aircraft for which the pilot is rated (or has sport pilot privileges for that category and class of aircraft, if the aircraft class rating is appropriate)
    2. When the pilot is the sole occupant in the aircraft
    3. When the pilot (except for a holder of a sport or recreational pilot certificate) acts as PIC of an aircraft for which more than one pilot is required
- SIC
- Flight and ground training received from an instructor
- Training received in a flight simulator, flight training device, or aviation training device from an instructor

c. Conditions of Flight

- Day or Night
- Actual Instrument
  - a A person may log instrument time only for that flight time when the person operates the aircraft solely by reference to instruments under actual or simulated instrument flight conditions

        - Simulated instrument conditions in a flight simulator, flight training device, or aviation training device
   - iii. Endorsements
      - a. Private Pilot Checkride (FAR 61.103)
         - Knowledge Test Endorsement
         - Flight Training Endorsement
      - b. Student Pilot Endorsements (Student Pilots – begins with FAR 61.81)
         - Presolo aeronautical knowledge
         - Presolo flight training/Presolo flight training at night
         - Solo Flight
         - Solo TO and LDG at another airport within 25 nm
         - Initial Solo XC/Repeated solo XC flights
         - Solo in Class B airspace/Solo to or from an airport in Class B
         - TSA Endorsement
   - iv. Regulatory Compliance (FAR 61.59)
      - a. False entries to maintain currency are basis for suspension/revocation of certificates, licenses, ratings, or authorizations
         - No person may make any fraudulent or intentionally false entry into any logbook, record, or report that is required to be kept, made, or used to show compliance with any requirement for the issuance or exercise of the privileges of any certificate, rating, or authorization
         - This is grounds for suspending or revoking any airman certificate, rating, or authorization held by that person
      - b. The FAA can and does perform random logbook/currency checks
         - Not maintaining the required currency can get your license revoked
      - c. Regulatory compliance is for your safety and the safety of others. Maintain currency and proficiency!

2. **Privileges and Limitations** (FAR 61.113)
   - A. A Private Pilot may not:
      - i. Act as PIC of an aircraft carrying passengers or property for compensation or hire
      - ii. 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
   - B. A Private Pilot may:
      - i. Act as PIC for compensation/hire if incidental to the business and no passengers or property are carried for compensation or hire
      - ii. Be reimbursed for operating expenses directly related to search and location operations
         - a. Provided it's controlled by Federal agency or an org that conducts search and locate ops
      - iii. Demo an aircraft to a potential buyer if have over 200 hours and are an aircraft salesman
      - iv. 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
      - v. Act as PIC for a charitable, nonprofit, or community event (under FAR 91.146)
      - vi. Act as PIC of an aircraft towing a glider (under FAR 61.69)

3. **Medical Certificates: Class, Expiration, Privileges, Temporary Disqualifications** (FAR 61.23)
   - A. Class and Privileges
      - i. A First-Class Medical Certificate is required when:

a. Exercising the PIC privileges of an airline transport pilot certificate
b. Exercising the second- in-command 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

ii. A Second-Class Medical Certificate is required when:
a. Exercising Second-in-command privileges of an airline transport pilot certificate under Part 121
b. Exercising the privileges of a commercial pilot certificate

iii. **A Third-Class Medical Certificate is required when:**
a. **Exercising the privileges of a private pilot**, recreational pilot, or student pilot certificate
b. Exercising the privileges of a flight instructor certificate and acting as PIC
c. Exercising the privileges of a flight instructor certificate and serving as a required flight crewmember
d. Taking a practical test in an aircraft for a recreational pilot, private pilot, commercial pilot, airline transport pilot, or flight instructor certificate
e. When performing the duties as an Examiner in an aircraft when administering a practical test or proficiency check

B. Expiration

i. First Class
a. Under 40 on the date of the examination - Expires at the end of the last day of the:
- 12th month for 1st class activities
- 12th month for 2nd class activities
- 60th month for 3rd class activities (under 40 years old)

b. 40 or over on the date of the examination - Expires at the end of the last day of the:
- 6th month for 1st class activities
- 12th month for 2nd class activities
- 24th month for 3rd class activities (over 40 years old)

ii. Second Class
a. When exercising the privileges of Commercial certificate
b. Under 40 on the date of the examination - Expires at the end of the last day of the:
- 12th month for 2nd class activities
- 60th month for 3rd class activities

c. 40 or over on the date of the examination - Expires at the end of the last day of the:
- 12th month for 2nd class activities
- 24th month for 3rd class activities

iii. Third Class
a. When exercising the privileges of a CFI, Private, Recreational, Student certificate, etc.
b. Under 40 on the date of the examination - Expires at the end of the last day of the:
- 60th month

c. 40 or over on the date of the examination - Expires at the end of the last day of the:
- 24th month

C. Temporary Disqualifications

i. FAR 61.53: Prohibition on Operations During Medical Deficiency
a. No person who holds a medical certificate may act as PIC, or in any other capacity as a required flight crewmember, while that person:
- Knows or has reason to know of any medical conditions that would make him or her unable to meet the requirements for the medical certificate necessary for the pilot operation; or

- Is taking medication or receiving other treatment for a medical condition that results in the person being unable to meet the requirements for the medical certificate necessary for the pilot operation

4. Operations requiring a Medical OR U.S. Driver's License

i. A person must hold and possess either a medical certificate or a US driver's license when:
   a. Exercising the privileges of a student, recreational or private certificate if the flight is conducted under the conditions and limitations set forth in FAR 61.113i (shown in part ii, below)
   b. Note: There are more operations that can be conducted with a medical or driver's license that can be found in FAR 61.23c. We're only focusing on the Student/Private Pilot information here

ii. FAR 61.113 (i): A private pilot may act as pilot in command of an aircraft without holding a medical certificate issued under part 67 of this chapter provided the pilot holds a valid U.S. driver's license, meets the requirements of FAR 61.23(c)(3) (shown in part iii, below), and complies with this section and all of the following conditions and limitations:
   a. The aircraft is authorized to carry not more than 6 occupants, has a maximum takeoff weight of not more than 6,000 pounds, and is operated with no more than five passengers on board; and
   b. The flight, including each portion of the flight, is not carried out:
      - At an altitude that is more than 18,000 feet above mean sea level;
      - Outside the United States unless authorized by the country in which the flight is conducted; or
      - At an indicated airspeed exceeding 250 knots; and
   c. The pilot has available in his or her logbook:
      - The completed medical examination checklist required under FAR 68.7; and
      - The certificate of course completion required under FAR 61.23(c)(3) (shown in part iii, below).

iii. FAR 61.23(c)(3): A person using a U.S. driver's license must meet the following requirements:
   a. The person must:
      - Comply with all medical requirements or restrictions associated with his or her U.S. driver's license;
      - At any point after July 14, 2006, have held a medical certificate issued under part 67 of this chapter;
      - Complete the medical education course set forth in FAR 68.3 during the 24-calendar months before acting as PIC in an operation conducted under FAR 61.113(i) and retain a certification of course completion in accordance with FAR 68.3 (b)(1) of this chapter;
      - Receive a comprehensive medical examination from a State-licensed physician during the 48 months before acting as pilot in command of an operation conducted under FAR 61.113(i) and that medical examination is conducted in accordance with the requirements in part 68 of this chapter; and
      - If the individual has been diagnosed with any medical condition that may impact the ability of the individual to fly, be under the care and treatment of a State-licensed physician when acting as pilot in command of an operation conducted under FAR 61.113 (i).
   b. The most recently issued medical certificate:
      - May include an authorization for special issuance;
      - May be expired; and
      - Cannot have been suspended or revoked.
   c. The most recently issued Authorization for a Special Issuance of a Medical Certificate cannot have been withdrawn; and

    d. The most recent application for an airman medical certificate submitted to the FAA cannot have been completed and denied.

5. **Documents Required to Exercise Private Pilot Privileges**
   A. FAR 61.3(a) & (c): No person may serve as a required pilot flight crewmember of a civil aircraft of the US, unless that person has, in their possession, a:
      i. Pilot Certificate
      ii. Photo ID
         a. Ex: Driver's License, Gov ID card, US Armed Forces ID card, Official Passport
      iii. An appropriate Medical Certificate
         a. Exceptions are listed in FAR 61.3(c)(2)
   B. FAR 61.51
      i. Upon a reasonable request from the Administrator, an authorized NTSB rep, or any Federal, State, or local law enforcement officer you must present your:
         a. Pilot Certificate
         b. Medical Certificate
         c. Logbook (or any other record required)
   C. So, at a minimum carry your Pilot Certificate, Photo ID, Medical, and Logbook

6. **Part 68 BasicMed Privileges and Limitations** (FAR Part 68)
   A. Overview
      i. Pilots may take advantage of the regulatory relief in the BasicMed rule and operate without an FAA medical certificate, or opt to continue to use their FAA medical certificate
         a. Under BasicMed, a pilot will be required to complete a medical education course, undergo a medical examination every four years, and comply with aircraft and operating restrictions
      ii. FAA BasicMed Info
      iii. FAA BasicMed FAQ
   B. Pilot Requirements
      i. Possess a U.S. driver's license
      ii. Have held a medical that was valid at any time after July 14, 2006.
      iii. Have not had the most recently held medical certificate revoked, suspended, or withdrawn.
      iv. Have not had the most recent application for medical certification completed and denied.
      v. Have completed a medical education course described in FESSA within the past 24 calendar months
         a. BasicMed Online Medical Course
      vi. Have received a comprehensive medical examination from a State-licensed physician within the previous 48 months.
         a. BasicMed Comprehensive Medical Examination Checklist (CMEC)
      vii. Be under the care and treatment of a physician for certain conditions
      viii. Make certain health attestations and agree to a National Driver Register check
   C. Aircraft Requirements
      i. Any aircraft authorized under federal law to carry not more than 6 occupants
      ii. Has a maximum certificated takeoff weight of not more than 6,000 pounds
   D. Basic Operating Requirements
      i. Carries not more than 5 passengers
      ii. Operates under VFR or IFR, within the United States, at less than 18,000' MSL, and not exceeding 250 knots
      iii. Flight not operated for compensation or hire

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Failure to distinguish proficiency vs currency**
   - A. Currency is the minimum required by law to legally fly
     - i. Although legal, more practice may be needed in order to be proficient and safe
   - B. Proficiency is a level of understanding and ability that creates a safe and competent pilot
     - i. Be proficient, not just current
     - ii. Even in the air, your mistakes can affect others
2. **Flying unfamiliar airplanes, or operating with unfamiliar flight display systems, and avionics**
   - A. Flying Unfamiliar Aircraft
     - i. Not all planes fly the same – different speeds, power settings, stall characteristics, procedures, etc.
     - ii. The first few flights in an unfamiliar aircraft should be with a CFI
       - a. Fly with a CFI until both you and the CFI feel you’re comfortable, safe and, competent
     - iii. Thoroughly review the Flight manual – know the airplane
   - B. Operating Unfamiliar Displays Systems and Avionics
     - i. The same mentality as operating unfamiliar aircraft applies
       - a. A thorough understanding is necessary before taking the aircraft solo or with passengers
       - b. Take as many flights as necessary until both you and the CFI feel you’re comfortable, safe, and competent

SKILLS

The applicant demonstrates the ability to:

1. Apply requirements to act as PIC under Visual Flight Rules (VFR) in a scenario given by the evaluator.

I.B. Airworthiness Requirements

References: 14 CFR Parts 39, 43, 91, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **General Airworthiness Requirements and Compliance for airplanes**
   - A. General Overview – What is Airworthiness (FAR 91.7 - Civil Aircraft Airworthiness)
     - i. No person may operate a civil aircraft unless it is in an airworthy condition
       - a. Airworthiness: Read the Airworthiness Certificate for the best definition of airworthiness
         - Certificate Authority and Basis for Issuance
           - a States the aircraft must conform to the type certificate
             1. The aircraft cannot be changed from its type certificate; must be in the condition it left the factory in. The only way the airplane can be changed is with a supplemental type certificate
         - Certificate Terms and Conditions
           - a States that the aircraft must be maintained in accordance with the FARS
     - ii. 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
       - a. This is the only FAR which mentions a visual inspection, i.e., Condition for safe flight
   - B. Certificate Locations and Expiration Dates (FAR 91.400)
     - i. FAR 91.417 provides a detailed explanation of the required records, what they must contain, and how long they must be kept
     - ii. FAR 91.400 describes the required inspections and the time allowed between each inspection
     - iii. The 100-Hour/Annual inspection as well as the inspections required for instruments and equipment necessary for legal VFR/IFR flight are located in the aircraft and engine logbooks
     - iv. Removing/Installing equipment not on the Equipment List
       - a. The weight and balance must be changed to indicate the new empty weight and Empty Weight Center of Gravity, and the equipment list must be revised to show the equipment that is actually installed
     - v. Repairs and Alterations
       - a. Major
         - 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
       - b. Minor
         - 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
     - vi. Be aware of where the specific certificates are located and their expiration dates
   - C. Required Documents (FAR 91.9 - Civil Aircraft Flight Manual, Marking, and Placard Requirements)
     - i. The following documents are required by the FARs (remember ARROW):
       - a. Airworthiness Certificate
       - b. Registration

c. Radio Operators License (if international)
d. Operating Limitations (Flight Manual/Owner's Manual)
e. Weight and Balance Certificate

ii. Required documents guiding FARs:

a. FAR 91.203 - Civil Aircraft: Certifications Required
   - Except as provided in §91.715, no person may operate a civil aircraft unless it has within it the following:
     a An appropriate and current **airworthiness certificate**
     b An effective U.S. **registration certificate** issued to its owner
       1. It must be displayed at the cabin or cockpit entrance so that it is legible to passengers or crew

b. FAR 91.9
   - No person may operate a U.S.-registered civil aircraft:
     a For which an Airplane or Rotorcraft Flight Manual is required by §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 §121.141(b); and
     b The **Weight and Balance** is included in the AFM, but is part of the type certificate and therefore required
     c For which an Airplane or Rotorcraft Flight Manual is not required by §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**
   - FAR 91.9 also states that the AFM is required in the airplane for planes registered after 1979
     a 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
   - FAR 91.9 also states that without the AFM, all placards, markings, etc. must be in the aircraft

D. Required Inspections

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 Airworthiness Directives that are due must be complied with
   - An annual inspection may be substituted for a required 100-hour 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 pounds (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 Inspection Authorization necessary (as is required 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 en-route 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 14 CFR part 91, section 91.215(a), it shall be tested and inspected within the preceding 24 months

f. **E**LT Inspection

- If operations require an ELT, it must be inspected every 12 calendar months

E. Airworthiness Directives and Special Airworthiness Information Bulletins

i. Airworthiness Directives (ADs)

a. Definition

- 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
- Similar to a recall on a car

b. ADs may be divided into two categories:

- Those of an emergency nature requiring immediate compliance prior to further flight
- Those of a less urgent nature requiring compliance within a specific period of time

c. ADs are regulatory in nature and shall be complied with unless a specific exemption is granted

d. It is the aircraft owner/operator's responsibility to ensure compliance with all pertinent ADs

- If an AD is not complied with by the designated date/time period, the aircraft is not airworthy and may not be flown

e. Compliance Records

- 14 CFR part 91.417 requires a record to be maintained showing the status of applicable ADs.
    - a 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

ii. Special Airworthiness Information Bulletins

a. A Special Airworthiness Information Bulletin (SAIB) is an information tool that alerts, educates, and makes recommendations to the aviation community.

b. SAIBs contain non-regulatory information and guidance that does not meet the criteria for an Airworthiness Directive (AD)

c. SAIB Database

F. Purpose and Procedure for Obtain a Special Flight Permit

i. 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

ii. Issued for the following reasons:
    a. Flying an aircraft to a base where repairs, alterations or maintenance are to be performed
    b. Delivering or exporting an aircraft
    c. Production flight testing new production aircraft
    d. Evacuating aircraft from areas of impending danger
    e. Conducting customer demonstration flights
    f. To allow the operation of an overweight aircraft for flight beyond its normal range where adequate landing facilities or fuel is not available.
iii. Obtaining a Special Flight Permit
    a. If a special flight permit is needed, assistance and the necessary forms may be obtained from the local FSDO or Designated Airworthiness Representative (DAR)

2. Pilot-Performed Preventive Maintenance

A. See FAR 43 for a detailed explanation of who can perform aircraft maintenance
    i. Annual inspections must be done by an Airframe and Powerplant mechanic (A&P) who holds an Inspection Authorization (IA)
    ii. 100-hour inspections only require an Airframe and Powerplant (A&P) mechanic
B. Pilot Preventive Maintenance
    i. FAR 43 Appendix A paragraph C lists 32 preventive maintenance tasks that a pilot can perform
    ii. AOPA's Guide to Preventive Maintenance
    iii. AC 43-12A: Preventive Maintenance

3. Equipment Requirements

Airworthiness requirements can be managed with or without a Minimum Equipment List (MEL). We'll discuss the more common option, operating without a MEL, first and then discuss operating with a MEL. Although not directly listed, the ACS requirements regarding Flying with Inoperative Equipment, Kinds of Operation Equipment List, and Required Discrepancy Records or Placards will be covered in the discussions below.

For further information, here's a great AOPA Article discussing MELs and Inoperative Equipment.

A. Airworthiness Equipment Requirements without an MEL
    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)
            - In order to defer the item or equipment, it must not be required for flight (as discussed below)
            - If the item is not required, it can be deferred
                a Inoperative equipment is deactivated (or removed) and placarded INOPERATIVE
                    1. Any necessary maintenance must be accomplished by certified maintenance personal
                    2. The item/equipment must be placarded INOPERATIVE
    iii. Follow these steps to decide whether equipment is required (FAR 91.213d):
        a. Check the Kinds of Operation Equipment List and Equipment List (KOEL)
            - Kinds of 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

b. Ensure it complies with the Type Certificate (rarely an issue, this should be common sense)
    a Definition
    b 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 Website (Search for TCDS, then find your specific aircraft)
  - 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 Type Certificate cannot be changed without a supplemental type certificate
      1. For example, you can't just decide to put a turbine engine in your Cessna 172

c. Airworthiness Directives (ADs)
  - 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 Similar to 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
  - 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.
      1. 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

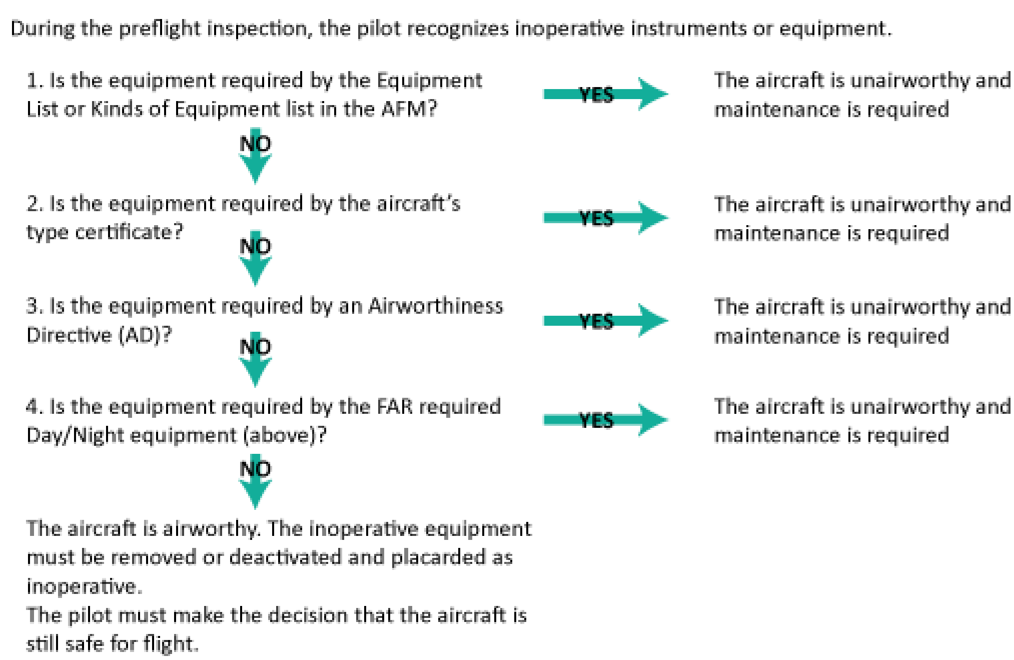
d. Does it comply with 14 CFR 91.205: Required Instruments and Equipment for Day and Night VFR Flight?
  - Visual-Flight Rules (Day), The following instruments and equipment are required:
    a Remember: TOMATO FFLAMES
    b **T**achometer for each engine
    c **O**il pressure gauge for each engine
    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 **M**agnetic compass
    - m **E**mergency Locator Transmitter
    - n **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

e. If the inoperative equipment is not required:

- The inoperative instruments and equipment are removed from the aircraft, the cockpit control placarded, and the maintenance recorded in accordance with 14 CFR 43.9; or
- The inoperative instruments and equipment are deactivated and placarded "Inoperative."
    - a If deactivation of the inoperative instrument or equipment involves maintenance, it must be accomplished and recorded, and the pilot or mechanic can determine that the inoperative instrument or equipment does not constitute a hazard to the aircraft

Inoperative Equipment Decision Sequence



B. Airworthiness Equipment Requirements with a MEL

i. A MEL is a precise listing of instruments, equipment, and procedures that allows an aircraft to be operated with inoperative equipment

a. Basically, it combines FAR 91.205, the Kinds of Equipment List, ADs and the 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 (as briefly described in 91.213)
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
d. If maintenance parts are not available at your location, a special flight permit can be obtained

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Inoperative Equipment Discovered Prior to Flight

A. Understand the procedures associated with the aircraft you are flying (MEL or no MEL) and how to apply those procedures when inoperative equipment is found
   i. In the case of a MEL, simply do what it says, otherwise follow the flow and determine if the equipment is required based on the FARs, KOEL, ADs, etc.
B. Ensure the equipment is repaired, removed, placarded, as required and recorded appropriately

SKILLS

The applicant demonstrates the ability to:

1. Locate and describe aircraft airworthiness and registration information.
2. Determine the aircraft is airworthy in a scenario given by the evaluator.
3. Apply the procedures for operating with inoperative equipment in a scenario given by the evaluator.

I.C. Weather Information

References: 14 CFR part 91**,** Aviation Weather (AC 00-6), Aviation Weather Services (AC 00-45), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Acceptable Sources of Weather Data for Flight Planning Purposes**
   A. AviationWeather.gov
      i. National weather service
   B. Weather Briefer
   C. Apps that link to this information
   D. Aviation weather only looks ahead so far. When preflight planning further out (days or weeks) use your local weather or reliable websites to get a picture of what to expect and whether or not the flight is currently worth planning
2. **Weather Products Required for Preflight Planning, Current and Forecast Weather for Departure, En Route, and Arrival Phases of Flight**
   A. See Aviation Weather below for full descriptions of various weather reports useful to planning
   B. METARs, TAFs and GFAs are the backbone of weather planning
      i. METARs cover the current condition at the airports you intend to use as well as those enroute
      ii. TAFs predict conditions at your proposed departure time as well as arrival time at the destination
      iii. For airports without a TAF, the GFA can help to fill in the blanks
   C. AIRMETs, and SIGMETs
3. **Meteorological Weather:**
   A. Atmospheric Condition and Stability
      i. Stability Chart
   B. Wind
      i. METARs, TAFs, Winds and Temperature Aloft charts
   C. Temperature
      i. METARs, TAFs, Winds and Temperature Aloft charts
   D. Moisture/Precipitation
      i. METARs, TAFs, Radar Summary, Prog Charts
   E. Weather System Formation
      i. Prog Charts, Radar Summary, SIGMETs
   F. Clouds
      i. METARs, TAFs, Radar Summary, GFA
   G. Turbulence
      i. AIRMETs, SIGMETs
   H. Thunderstorms and Microbursts
      i. SIGMETs, Prog Charts, Radar Summary
   I. Icing and Freezing Level Information
      i. Prog Charts, Freezing Level Charts
   J. Fog
      i. METARs, TAFs, Temp/Dew point, AIRMETs
   K. Frost
      i. METARs, TAFs, Temp/Dew point, AIRMETs

4. Flight Deck Displays of Digital Weather and Aeronautical Information
   A. Cockpit weather displays will differ based on the aircraft, glass cockpit, and subscription services purchased by the pilot/flight school
   B. The student should be capable of competently using whatever is available (for example, satellite weather on the G1000 and the various options and the information it can provide)

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Factors involved in making the Go/No Go and Continue/Divert Decisions**
   A. By compiling an overview of the weather conditions from the time of departure to arrival at your destination, both on the ground and at altitude, the pilot can make a well-informed decision as to whether the weather is conducive to Going or Not going
   B. Circumstances that Would Make a Divert Prudent
      i. Less than VFR weather conditions
         a. Obviously if the pilot cannot maintain VFR conditions, it would be prudent to divert to another airfield with improved weather conditions preferably above VFR minimums
      ii. Winds
         a. Strong winds, whether down the runway or crosswind, can be hazardous to a pilot. Keep in mind that strong winds often come with additional weather
      iii. Rain
         a. Although a pilot may be able to maintain VFR minimums during rainy weather, it may not be safe. Just because the minimums are there doesn't mean the pilot should continue. Weigh all the factors.
      iv. Potential Weather
         a. Predicted weather near your arrival time may make a divert prudent. Don't risk safety.
         b. Weather can and often does change en route. Surprise! Weather reports (like weather reporters) aren't always accurate.
            - As weather changes, so should your plan
               a Have alternates
               b Have backups
      v. Rapidly changing weather, thunderstorm potential, temperatures dropping toward the dew point, front passage, etc.
      vi. Many conditions can affect the risk – the moral of the story is to understand the expected weather at your departure, arrival and en route points, have a backup plan, and use it when necessary.
   C. Personal Weather Minimums
      i. Weather is likely the most hazardous part of any private pilot flight and therefore minimums should be established so that a go/no go decision can be made based on set standards and not on the individual situation.
         a. For example, if you have decided that you won't fly with crosswinds greater than 15 knots or ceilings reported to be less than 5,000' you can stick to those minimums no matter the situation (rather than stretching your limits based on the situation – ex: you really want to get somewhere now, vs tomorrow). Stick to your mins!
      ii. Flying is a continual process of decision making
      iii. Changing conditions en route may turn a Go decision into a No Go – have a backup plan!
   D. Hazardous Weather Conditions to Include Known or Forecast Icing or Turbulence Aloft

        i. A thorough weather briefing should provide the pilot the ability to avoid hazardous weather conditions, or cancel/delay the flight until conditions improve
            a. Do not knowingly fly into forecast icing or turbulence the aircraft is not rated for or capable of handling
        ii. When unexpected hazardous weather conditions are encountered use all resources available to exit the conditions and continue along a safe route or divert
            a. Resources can include: ATC, other pilots, weather reports, avionics (if equipped), etc.

2. **Onboard Weather Equipment Limitations**
    A. Weather equipment can break and provide no information or faulty information
    B. Although somewhat uncommon, weather can vary over short distances
        i. Ex: Differing winds on different parts of the field
    C. Not all AWOS can differentiate between rain, snow and ice
    D. Certain things, like turbulence, may not be able to be displayed due to equipment limitations
3. **Aviation Weather Reports and Forecasts Limitations**
    A. Weather reports (like weather reporters) aren't always accurate.
    B. Continue to build a picture of what the weather looks like en route
        i. Use in flight displays (Satellite weather, G1000, foreflight, etc.)
        ii. Talk to ATC, ask about weather ahead. Ask for PIREPs. Listen on the radio to what other pilots are experiencing
        iii. Contact a Flight Service Station (122.0 or as published) for weather information
4. **Inflight Weather Resources Limitations**
    A. Modern technology has greatly improved the ability to monitor en route weather from the aircraft
        i. But satellite reception and outages can limit your abilities – don't depend on the technology, always have a backup (paper info)
    B. Flight Watch no longer exists, eliminating a source of en route weather info
        i. Instead, contact an FSS for an in-flight weather report
    C. Some pilots may not have access to an FSS or digital display, in this case ensure you have a strong understanding of the weather and potential hazards prior to departure

AVIATION WEATHER:

1. **Importance of a Thorough Weather Briefing**
    A. [FAR 91.103](https://www.ecfr.gov) – 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
2. **Weather Information Sources**
    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

C. 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

3. Weather Reports and Charts

A. METAR, TAF, and GFA
   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

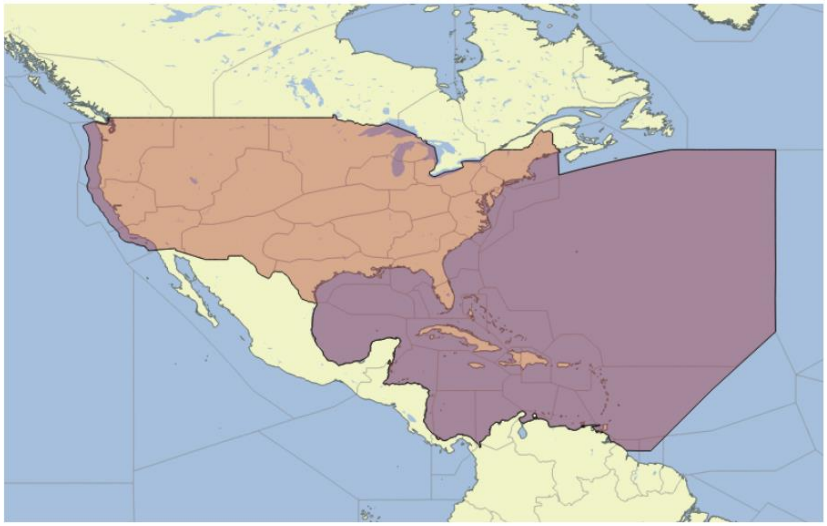
EXAMPLE:
TAF
KPIR 111130Z 111212 15012KT P6SM BKN090
TEMPO 1214 5SM BR
FM1500 16015G25KT P6SM BKN080 OVC150 PROB40 0004 3SM TSRA BKN030CB
FM0400 1408KT P6SM SCT040 OVC080 TEMPO 0408 3SM TSRA OVC030CB
BECMG 0810 32007KT=

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 18 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
      - Describes conditions produced by weather systems such as high- and low-pressure areas, air masses, and fronts. Predicts conditions that affect flight over 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 phenomena
- 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. Surface Analysis Chart

i. Depicts an analysis of the current surface weather
ii. Computer prepared report transmitted every 3 hours covering contiguous 48 states/adjacent areas
iii. Shows high/low pressure, fronts, temp/dewpoint, wind direction/speed, weather, visual obstruction
iv. Surface weather observations for reporting points across the US are also depicted on this chart. Each of these reporting points is illustrated by a station model. 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 – Many different weather symbols are used to describe the current weather
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)

C. Radar Summary Chart
  i. A graphically depicted collection of radar weather reports (SDs) displaying areas of precipitation as well as information regarding the characteristics of precipitation
  ii. The chart is published hourly at 35 min past the hour
  iii. A radar summary chart includes:
    a. No information – If info isn't reported it will say "NA." if no echoes are detected, it will say "NE"
    b. Precipitation Intensity Contours – Described as one of 6 levels and shown by 3 contour intervals
    c. Height of Tops – The heights of the echo tops are given in hundreds of feet MSL
    d. Movement of Cells –Indicated by an arrow pointing in the direction of movement, speed in knots is at the top of the arrow heard ("LM" indicates little movement)
    e. Type of Precipitation - Marked using specific symbols (not those used on the METAR)
    f. Echo Configuration – Echoes are shown as being areas, cells, or lines
    g. Weather Watches – Depicted by boxes outlined with heavy dashed lines
  iv. Limitations
    a. Only depicts areas of precipitation
    b. Will not show areas of clouds and fog with no appreciable precipitation,
    c. Will not show the heights of the tops and bases of the clouds
  v. Depiction of current precipitation, should be used with current METAR and weather forecasts

D. Winds and Temperatures Aloft Chart (FB)
  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 230° 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

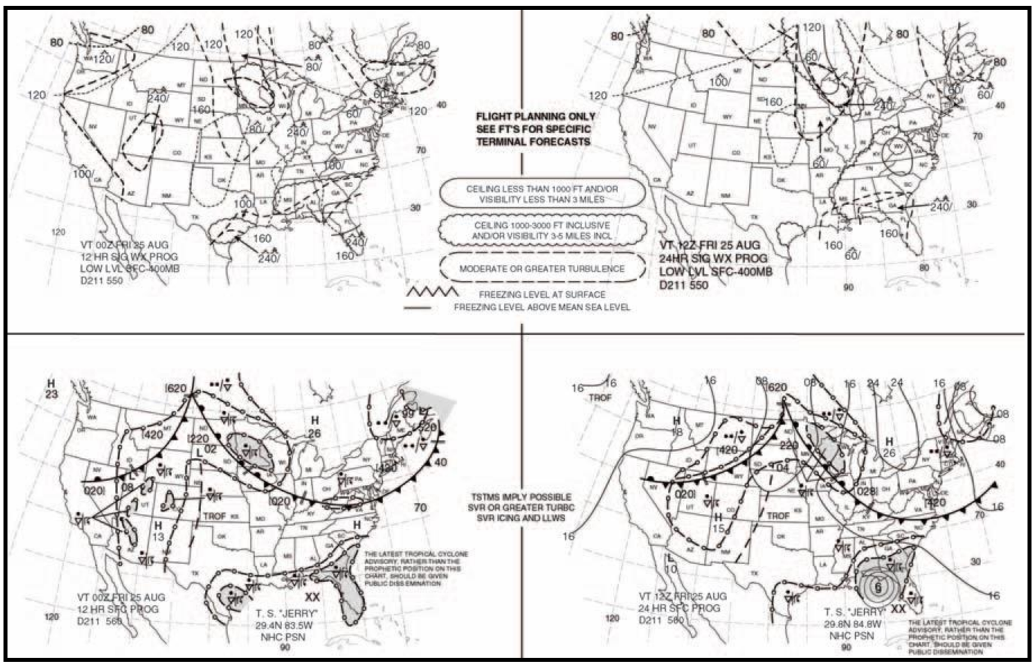
FD	3000	6000	9000	12000	18000	24000	30000
AMA		2714	2725+00	2625-04	2531-15	2542-27	265842
DEN			2321-04	2532-08	2434-19	2441-31	235347

EXPLANATION:
The heading indicates that this FB 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.

E. Significant Weather Prognostic Charts
   i. Portray forecasts of selected weather conditions at specified valid times
      a. Comprehensive set of observed weather conditions are extended forward to become forecasts
   ii. Forecasts are made for various periods of time
      a. Each valid time is the time at which the forecast conditions are expected to occur
         - Valid time is printed on the lower left-hand corner of each panel
         - A 12-hour prog is a forecast of conditions with a valid time 12 hours after the observed time
            a EX: A 12-hour forecast based on 00Z observations is valid at 12Z
      b. Forecasts are issued four times a day at 0000Z, 0600Z, 1200Z, 1800Z
   iii. Altitude information is referenced to MSL. (Below 18,000’ are true, above 18,000’ are pressure)
   iv. The prog charts are generated for two general time periods
      a. Day 1 progs are forecast for the first 24-hour period and are prepared for 2 altitude references
      b. Day 2 progs are forecast for the second 24-hour period
   v. Charts are available for low-level significant weather and high-level significant weather
      a. Low Level Chart
         - A day 1 forecast of significant weather for the conterminous US
         - Weather information pertains to the layer from surface to FL240 (400 mbs)
            a The information is provided for two forecast periods: 12 hours and 24 hours
         - The chart is composed into 4 panels:
            a The upper two panels depict the 12 and 24-hour significant weather progs
               1. Displays forecast flying categories (VFR/IFR/MVFR), freezing levels, turbulence
                  a. A legend on the chart illustrates symbols and criteria used for these conditions
            b The lower two panels depict the 12 and 24-hour Surface Progs

        1. Displays forecast positions/characteristics of pressure systems, fronts, precipitation
            a. Standard symbols are used to show fronts and pressure centers
            b. Direction of movement of the pressure center is depicted by an arrow
            c. The speed is in knots and is shown next to the arrow
            d. Areas of forecast precipitation and thunderstorms are outlined
                i. Shaded areas of precip indicate at least ½ the area is affected by the precip
                ii. Unique symbols indicate the type of precipitation and the manner it occurs
- Using the chart
    a Provides an overview of selected flying weather conditions up to 24,000 ft. for day 1
    b Surface winds can be inferred from surface pressure patterns
    c Structural icing can be inferred in areas with clouds and precipitation above freezing levels, and in areas of freezing precipitation
    d Use to obtain an overview of the progression of weather during day 1

EXAMPLE:

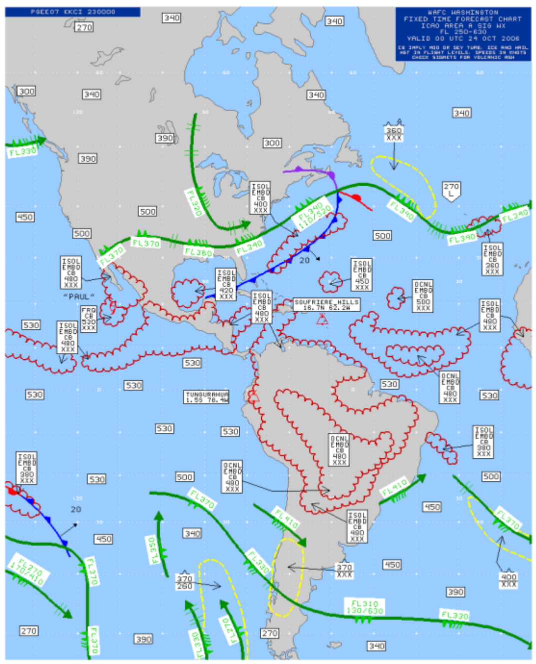


b. 36 and 48-hour Surface Prog
- A day 2 forecast of general weather for the conterminous US
    a An extension of the day 1 low-level prog chart issued from the same observed data base
- Chart is issued two times daily at 0000Z and 1200Z and valid 36/48 hours after observed
    a EX: A chart issued based on 00Z Tuesday observations has a 36-hour valid time of 12Z Wednesday and a 48-hour valid time of 00Z Thursday
- Chart is composed of two panels and a forecast discussion
    a The two panels contain the 36 and 48-hour surface progs
- Panels display forecast positions/characteristics of pressure patterns, fronts, precipitation
    a Provides info regarding surface weather forecasts, includes a discussion of the forecast
        1. Forecast discussion: discussion of the day 1 and day 2 forecast package, including identification/characterization of weather systems and associated weather conditions portrayed on the prog charts
    b Standard symbols are used to show fronts and pressure centers
    c Precipitation areas are outlined on each panel

- Using the chart
    a The 36 and 48-hour surface prog provides general weather conditions outlook for day 2
    b The chart can be used to assess the progression of weather through day 2

c. High-Level Significant Weather Prog
- A day 1 forecast of significant weather covering a large portion of the Northern Hemisphere and a limited portion of the Southern Hemisphere
- Weather information pertains to the layer from above 24,000 to 60,000 feet
    a Conditions routinely appearing are jet streams, CB clouds, turbulence, and tropopause heights, surface front are also included to add perspective
- Tropical cyclones, squall lines, eruptions, sandstorms, dust storms will appear
- Each prog chart is issued 4 times a day and is valid times at 00Z, 06Z, 12Z, 18Z
- Using the chart
    a Used to get an overview of selected flying weather conditions above 24,000 feet

EXAMPLE:



vi. Prognostic charts are an excellent source of information for preflight planning; however, this chart should be viewed in light of current conditions and specific local forecasts

F. Convective Outlook Chart

i. Delineates areas forecast to have thunderstorms

ii. Presented in two panels

a. Left-hand panel is the Day 1 Convective Outlook
- Outlined areas are where thunderstorms are forecasted during the day 1 period
    a Outlook issued qualifies the risk (SLGT, MDT, HIGH) and areas of general thunderstorms
- Issued 5 times daily
    a 1st issuance is 06Z and is the initial Day 1 Outlook, valid 12Z until 12Z the following day
    b The other issuances are 1300Z, 1630Z, 2000Z, and 0100Z
    c All issuances are valid until 12Z the next day

b. The right-hand panel is the Day 2 Convective Outlook
- Contains the same information as the Day 1 Outlook
- Issued 2 times a day

        a The first issuance is at 0830Z during standard time and 0730Z during daylight time
        b Updated at 1730Z
    - The timeframe covered is from 12Z the following day to 12Z the next day
        a EX: If today is Mon, the Day 2 Outlook will cover 12Z Tuesday to 12Z Wednesday

c. Levels of Risk
    - Risk areas come in 3 varieties based on the number of severe thunderstorm reports per geographical unit and forecaster confidence
        a SEE TEXT: Slight risk was considered, but at the time of the forecast, was not warranted
        b SLGT risk: Well-organized severe storms expected but in small numbers/low coverage
        c MDT risk: Greater concentration of severe storms/greater magnitude of severe weather
        d HIGH risk: A major weather outbreak is expected, with great coverage
        e In addition to the risk areas, general Thunderstorms are outlined, but not labeled

NOTATION	EXPLANATION
SEE TEXT	A slight risk was considered, but at the time of the forecast, was not warranted
SLGT	A high probability of 5-29 reports of 1 inch or larger hail, and/or 3-5 tornadoes, and/or 5-29 wind events,…or…a low/moderate probability of moderate to high risk being issued later if some conditions come together
MDT	A high probability of at least 30 reports of hail 1 inch or larger; 6-19 tornadoes; or numerous wind events (30)
HIGH	A high probability of at least 20 tornadoes with at least two of them rated F3 (or higher), or an extreme derecho causing widespread (50 or more) wind events with numerous higher-end wind (80 mph or higher) and structure damage reports

d. Using the chart
    - A flight planning tool used to determine forecast areas of thunderstorms

G. ASOS, AWOS, and ATIS

i. ASOS (Automated Surface Observing System)

a. Continuous min-by-min observations to generate a METAR and can provide other information

b. Transmits a SPECI report whenever it determines a significant change in conditions

c. Types of Observations
    - Every ASOS contains:
        a Cloud height indicator
        b Visibility Sensor
        c Precipitation identification sensor
        d Freezing rain sensor (at select sites)
        e Pressure sensors
        f Ambient temperature and dew point temp sensors
        g Anemometer (wind direction & speed)
        h Rainfall accumulation sensor
    - Some include precipitation discriminator which differentiates liquid/frozen precipitation
        a If it has this capability, it's designated as A02 in the remarks section (otherwise A01)
    - Lightning detection equipment is installed at select ASOS installations

d. Limitations
    - ASOS cannot distinguish between stratus and cumulonimbus clouds
    - Limited in its ability to identify restrictions to visibility
        a No prevailing, sector, tower visibility (Input from a trained human observer is integral)

e. Levels of service
    - LEVEL A- The highest – typically available at major airports like those in or near Class B
    - LEVEL B – Has human observers available 24 hours a day
    - LEVEL C – At airports with part-time towers (Human augmentation ends when tower closes)

- LEVEL D – At smaller, nontowered airports meeting the FAA or NWS criteria for the ASOS
    - a Unattended, and will always contain the AUTO designation when in a METAR

ii. AWOS (Automated Weather Observing System)
   a. First widely installed automated weather data gathering system at US airports
   b. AWOS is available in lesser configurations without all the types of observations listed above
   c. Levels of service:
      - AWOS-A: Only reports the altimeter setting
      - AWOS-1: Also measures/reports wind speed, direction, gusts, temperature, and dew point
      - AWOS-2: Adds visibility information
      - AWOS-3: Most capable – also includes cloud/ceiling data (essentially equivalent to ASOS)
         - a Like ASOS, AWOS-3 can include precipitation discrimination sensors indicated by A02
         - b Lightning detection is also an enhancement for selected AWOS-3 sites
   d. Difference between ASOS/AWOS is ability to detect/report significant changes in sfc weather
      - AWOS transmits 3 reports per hour at fixed intervals and cannot issue a special report

iii. ATIS (Automatic Terminal Information Service)
   a. A continuous broadcast of recorded non-control information in busier terminal areas
   b. Contains essential info - weather, active runways/approaches, other required info (NOTAMs)
      - Data may be entered by hand, come from a METAR, or be taken directly from sensors
   c. In its simplest form, ATIS is a continuously played recording of a person reading the information
   d. Updated when there is a significant change in the information; given a letter designation
   e. Re-recorded at every update (often several times per hour)
   f. Modern systems are automated and only require a controller for failures/unusual activities
   g. Some airports have separate ATIS for arriving/departing aircraft, each on its own frequency

4. In-Flight Weather Advisories

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

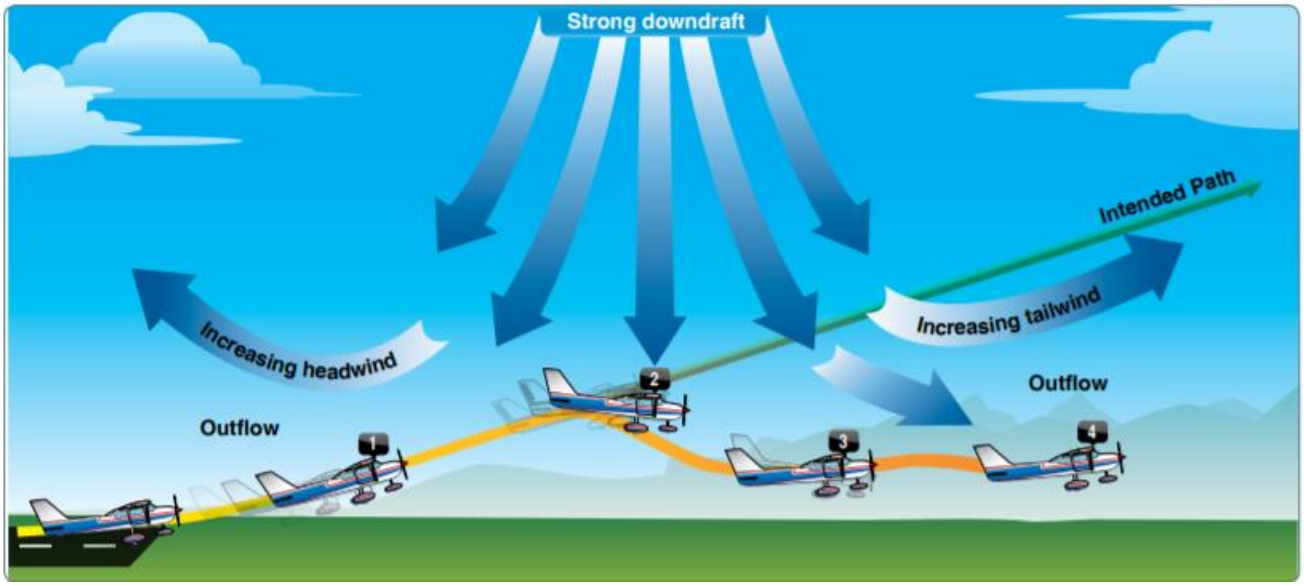
C. SIGMET (WS)
   i. In flight advisory concerning non-convective weather that is potentially hazardous to all aircraft
   ii. Severe icing/extreme turbulence/Clear Air Turbulence (CAT) not associated with Thunderstorms; dust/sand storms lowering visibility to less than 3 miles and volcanic ash
   iii. 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. PIREPS
   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
   ii. PIREPS fill the gaps between reporting stations

5. Recognizing Weather Hazards

A. Hazards can be recognized through proper interpretation of aviation weather charts, reports, etc.
   i. GFA, WST, WS, WA, Significant Weather Prognostic charts
B. Also, utilizing weather information resources will allow hazards to be recognized
   i. LLWAS, PIREPS, Convective Outlook, METARs, etc.
C. Wind Shear
   i. What is it?
      a. A sudden, drastic change in wind speed and/or direction over a very small area
      b. While wind shear can occur at any altitude, low-level wind shear is especially hazardous due to the 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. Wind shear can subject an aircraft to violent updrafts and downdrafts, as well as abrupt changes to the horizontal movement of the aircraft
      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
         - The most severe type of wind shear
            a Associated with convective precipitation into dry air at cloud base
         - Typical Microburst
            a Horizontal diameter of 1-2 miles
            b Depth of 1,000’
            c Lifespan of 5-15 minutes
            d Downdrafts of up to 6,000 feet per minute
            e Headwind losses of 30-90 knots (seriously degraded performance)
            f Strong turbulence and hazardous wind direction changes
         - Flying through a Microburst
            a During an inadvertent takeoff into a microburst, the plane may first experience a performance-increasing headwind (1)
            b Followed by performance-decreasing downdrafts (2)
            c Followed by a rapidly increasing tailwind (3)
               1. This can result in terrain impact or flight dangerously close to the ground (4)
            d An encounter during approach involves the same sequence of wind changes and could force the plane to the ground short of the runway



- Indications
    - a Visual
        1. Intense rain shaft at the surface, but virga at cloud base
        2. 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 detect microbursts well above 90% detection rate requirement established by congress
        3. Many airports, especially smaller airports, have no wind shear systems
            a. AC 00-54 – FAA Pilot Wind Shear Guide
                i. Includes information on how to recognize the risk of a microburst encounter, how to avoid an encounter, and the best strategy for escape
                ii. Tailored to jet aircraft, but still very useful information

iii. Handling Wind Shear

a. If at all possible, avoid it

- Never conduct traffic pattern operations in close proximity to an active thunderstorm
    - a Be alert for visual cues and any alerting systems
    - b Do not takeoff if wind shear is in the area
- LLWAS (Low Level Wind Shear Alerting System)
    - a If available can warn of impending wind shear
- PIREPS
    - a Can be very informational/helpful if a pilot has reported wind shear in the area

6. Go/No Go Decision

A. Weather factors must be considered in relation to the route of flight, aircraft and equipment to be used, as well as the pilot

i. Can the plane and equipment handle the flight as planned?

ii. Is the route safe?

B. Set limits and don't bend them

i. For example, numerous weather conditions may be an automatic no go (thunderstorms/squall lines, 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. Physical/Mental condition
    i. Sick, tired, upset, depressed – These factors can greatly affect the ability to handle any problem
    ii. IMSAFE checklist

D. Recent Flight Experience
    i. Don't go beyond your abilities or the aircraft's abilities
    ii. Ex: Are you comfortable in MVFR if you haven't flown in a while

E. Flying is a continual process of decision making throughout the entire flight
    i. Discontinue the flight or divert, if necessary

SKILLS

The applicant demonstrates the ability to:

1. Use available aviation weather resources, obtain an adequate weather briefing, and correlate weather information to make a competent go/no-go decision.
2. Discuss the implications of at least three of the conditions listed in K3a through K3k above, using actual weather or weather conditions in a scenario provided by the evaluator.

I.D. Cross-Country Flight Planning

References: 14 CFR Part 91, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM, Navigation Charts, Chart Supplements, NOTAMs

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Route Planning, including Special Use Airspace**
    - A. First, plan the route
        - i. Once you have decided on the best route, draw a line (or lines depending on your course) from Point A to Point B
            - a. If the route is direct, the course will consist of a single straight line
            - b. If not, it will consist of 2 or more straight line segments
                - For example, a VOR station which is off the direct route but will make navigating easier
        - ii. Considerations when choosing a route
            - a. Direct is the shortest and quickest route, but may not always be the best
            - b. Terrain
                - High terrain may need to be avoided
                - Terrain can also be used as checkpoints/guiding features in order to maintain course, especially in the case of pilotage
                    - a EX: Keep a mountain range to the West, or keep a river on the right, etc.
            - c. Navaids
                - Flying on airways provides a navigation backup in the case that GPS fails
                    - a Choose airways that provide the safest route in regards to terrain, airspace, weather, etc.
                    - b Check NOTAMs to ensure the navaids are operational
                    - c Have the frequencies marked or written down to provide easy access when busy in the cockpit
                    - d Ensure the navaid's range is appropriate for the route/leg length planned
                - Airways (especially at a navaid where multiple airways converge) are traffic magnets, be vigilant in looking for other aircraft
            - d. Alternates
                - Always ensure there are airports on or near the course that can be used in the case of an emergency
                - Be familiar with the airports and ensure they are useful alternates
                    - a Runway length, capabilities, TFRs, NOTAMs etc. should be reviewed to ensure the airport is useful to you and your aircraft
            - e. Airspace
                - Understand the requirements for whatever airspace you may enter
                    - a For example, in Class B, specific clearance to enter is required vs Class C where the controller simply has to acknowledge you with your call sign
                - Special Use Airspace should usually be avoided
                    - a Be aware of the requirements for different types of airspace. Research the hours of operation as listed on the charts for the different Special Use Areas. Although some special use airspace is not prohibited (MOAs), when they are active, it is smart to avoid them

iii. Always take into account terrain, airspace, navigation capabilities, alternate/emergency airfields, etc. when choosing the route

iv. There are different options on how to organize your route and checkpoints

   a. You can find the route first, and then find checkpoints to support the route, or you can find the checkpoints first and then draw the route. In both cases, all of the same factors are taken into account

B. Checkpoints – Recognizable points along your route of flight used to maintain your course

i. Top of Climb (TOC)

   - 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 info and desired cruising altitude calculate the distance to reach the top of climb
      - Rate of Climb can be calculated in the AFM (ex. 1,000 fpm)
      - Altitude to climb: Cruising 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 in the climb (TAS adjusted for wind) in order to find 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 visual checkpoint that corresponds with the TOC

ii. Top of Descent (TOD)

   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 (we'll use 1,000 fpm as an example)
      - Altitude to descend (Cruising altitude minus 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 * 150 kts/hr. = 13.25 nm
               a. 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

2. Altitude Selection

A. Decide what altitude you will fly the trip based on the direction of flight, terrain, fuel, etc.

B. From a magnetic course of 0-179 degrees (East), use odd thousands + 500'
  i. EX: 5,500'

C. From a magnetic course of 180-359 degrees (West), use even thousands + 500'
  i. EX: 8,500'

D. Choosing an altitude involves more than the direction of flight
  i. Airspace
    a. Depending on whether you want to/are able to fly through different types of airspace you may want to fly over or under the airspace
    b. There may be mandatory altitudes for VFR corridors through Class B airspace
    c. Avoid special use airspace as much as possible
  ii. Terrain
    a. Terrain is likely the most influential piece when choosing an altitude
    b. Make sure you can comfortably clear any terrain on your route of flight
        - Use the POH to check the aircraft's performance capabilities based on the current conditions
            a EX: On a hot, humid day with a lot of fuel/passengers the aircraft will not perform near as well as a cold, dry day with a light aircraft
  iii. Weather
    a. Weather conditions at different altitudes, especially when flying VFR can have a large say in the altitude flown
        - Cloud conditions – be sure to maintain required cloud clearances
        - Winds – Winds tend to be stronger at higher altitudes but can vary, look for winds that favor your route of flight (tailwinds, or weaker headwinds)
  iv. Fuel
    a. Fuel burns vary based on altitude and airspeed; ensure you've taken the fuel burn into account when choosing your altitude
    b. Remember fuel burn will vary based on winds. Make sure you're taking them into account, especially if it's a headwind
  v. Traffic
    a. Above 10,000' the VFR requirements increase because the 250-knot speed limit is removed, be cautious as aircraft approach much faster than below 10,000'
    b. Different types of airspace attract more traffic than others, avoid crowded areas as much as possible within the realm of safety
  vi. Checkpoint Visibility
    a. VFR pilotage and dead reckoning can be very difficult at high altitudes
    b. Check points become difficult to identify at high altitudes

vii. Glide Distance
   a. Ensure the altitude selected provides the ability to reach a safe area in the case of an engine failure/loss of power (preferably an airport)
      - This is especially important over water. In this case, climb to an altitude, if possible, that would allow for a power off glide that would at least allow the aircraft to return to land (preferably to a safe landing area)
      - If this is not possible, consider canceling the flight or be prepared for a worst-case scenario (ditching)
   b. Use the POH to determine the power off glide performance of the aircraft. Use that information to determine the altitude required to fly to ensure the aircraft can reach a safe landing area

3. En Route Calculations

A. Return to the Nav Log discussed above (TOC, en route waypoints, and TOD should be recorded) and start by finding the cruise True Airspeed for the trip and record it on your Nav Log
   i. Use the chart provided in the aircraft POH (make calculations based on expected conditions)

B. 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
   i. Input these distances in the Nav Log

C. Next, find the true course for each leg of the flight plan
   i. True Course (TC): Direction of the line connecting two points drawn on the chart and measured clockwise in degrees from True North
      a. North is always straight up when measuring true course
      b. Use your plotter to find the True Course

D. Adjust True Course for wind in order to get True Heading
   i. On the back of the flight computer calculate the Wind Correction Angle and add/subtract it to/from the True Course in order to get your True Heading (or just use a digital flight calculator)
      a. Add West, subtract East corrections (East is least, West is best is a decent memory aid)
      b. Also make a note of the Ground Speed for each leg of the flight on the Nav Log

E. Finally, adjust the True Heading in order to find Magnetic Heading
   i. Magnetic Heading: Magnetic variation is applied to True Heading
      a. Using the isogonic lines depicted on the sectional chart, add or subtract the necessary number of degrees in order to find the magnetic heading required to maintain your course (again, East is least (minus), and West is best (plus))

F. If necessary, get your Compass Heading by adjusting for Deviation with the correction card near the compass of your aircraft

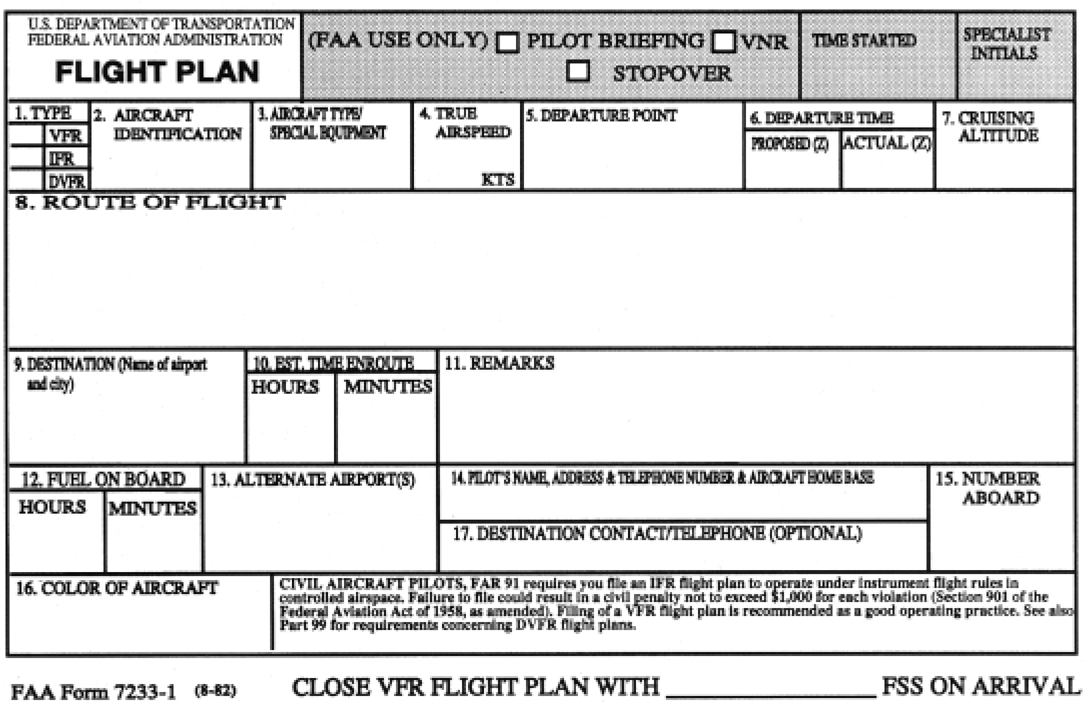
G. At this point your Nav Log should have all of the checkpoints listed, each with a distance, a True Course, True Heading, Magnetic Heading, Compass Heading, as well as an altitude and Ground Speed

H. Next is the Time and Distance Information
   i. Since you already have the Distance and Ground Speed between each point, calculate the estimated amount of time for each leg
      a. Distance = Rate x Time, so Time = Distance/Rate (or Ground Speed)
      b. This will give you your ETA
         - Be careful to adjust your arrival times when crossing time zones
   ii. Although as a private pilot the majority of your flying will be based on your own schedule and therefore on local time, aviation as a whole is coordinated in Zulu time (UTC)
      a. Flight plans should be filed in Zulu time
      b. Convert your Departure and Arrival times to Zulu
      c. Understanding how to adjust your times to Zulu time will make communicating with various agencies much easier

UTC Conversion (Add to Local Time)	Pacific Standard 8 hrs	Mountain Standard 7 hrs	Central Standard 6 hrs	Eastern Standard 5 hrs
	Pacific Daylight 7 hrs	Mountain Daylight 6 hrs	Central Daylight 5 hrs	Eastern Daylight 4 hrs

I. Fuel Requirements
   i. Finally, use the Time for each leg in order to find the fuel burn for each leg
      a. Using the POH find your fuel burn for Climb, Cruise, and Descent
         - It will likely be shown in Gallons per hour
         - Convert your time for each leg into hours and then find the gallons burned per leg
            a This can be done using the flight computer or a calculator
   ii. Of course, all of this should be entered in the Nav Log
   iii. FAR Requirements (FAR 91.151)
      a. Fuel to fly to the first point of intended landing, and after that for at least 30 minutes during the day, or 45 minutes at night.
         - This is at normal cruising speed and considering wind and forecast weather
   iv. Plan fuel stops based on personal comfort, and at a minimum, on regulatory requirements
      a. Plan accordingly based on the fuel burn and time en route from the nav log you created

4. VFR Flight Plan Elements



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
FLIGHT PLAN
(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR ☐ STOPOVER
TIME STARTED
SPECIALIST INITIALS
1. TYPE VFR IFR DVFR
2. AIRCRAFT IDENTIFICATION
3. AIRCRAFT TYPE/ SPECIAL EQUIPMENT
4. TRUE AIRSPEED KTS
5. DEPARTURE POINT
6. DEPARTURE TIME PROPOSED (Z) ACTUAL (Z)
7. CRUISING ALTITUDE
8. ROUTE OF FLIGHT
9. DESTINATION (Name of airport and city)
10. EST. TIME ENROUTE HOURS MINUTES
11. REMARKS
12. FUEL ON BOARD HOURS MINUTES
13. ALTERNATE AIRPORT(S)
14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE
15. NUMBER ABOARD
17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)
16. COLOR OF AIRCRAFT
CIVIL AIRCRAFT PILOTS, FAR 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.
FAA Form 7233-1 (8-82) CLOSE VFR FLIGHT PLAN WITH ________________ FSS ON ARRIVAL

A. FAA Domestic Flight Plan
   i. Block 1. Check the type flight plan. Check both the VFR and IFR blocks if composite VFR/IFR.
   ii. Block 2. Enter your complete aircraft identification including the prefix "N" if applicable.
   iii. Block 3. Enter the designator for the aircraft, or if unknown, consult an FSS briefer.
   iv. Block 4. Enter your true airspeed (TAS).
   v. Block 5. Enter the departure airport identifier code, or if unknown, the name of the airport.
   vi. Block 6. Enter the proposed departure time in Coordinated Universal Time (UTC) (Z). If airborne, specify the actual or proposed departure time as appropriate.

vii. Block 7. Enter the appropriate VFR altitude (to assist the briefer in providing weather and wind information)
viii. Block 8. Define the route of flight by using NAVAID identifier codes and airways.
ix. Block 9. Enter the destination airport identifier code, or if unknown, the airport name. NOTE− Include the city name (or even the state name) if needed for clarity.
x. Block 10. Enter your estimated time en route in hours and minutes.
xi. Block 11. Enter only those remarks that may aid in VFR search and rescue, such as planned stops en route or student cross country, or remarks pertinent to the clarification of other flight plan information, such as the radiotelephony (call sign) associated with a designator filed in Block 2, if the radiotelephony is new, has changed within the last 60 days, or is a special FAA-assigned temporary radiotelephony. Items of a personal nature are not accepted.
xii. Block 12. Specify the fuel on board in hours and minutes.
xiii. Block 13. Specify an alternate airport if desired.
xiv. Block 14. Enter your complete name, address, and telephone number. Enter sufficient information to identify home base, airport, or operator. NOTE− This information is essential in the event of search and rescue operations.
xv. Block 15. Enter total number of persons on board (POB) including crew.
xvi. Block 16. Enter the predominant colors.
xvii. Block 17. Record the FSS name for closing the flight plan. If the flight plan is closed with a different FSS or facility, state the recorded FSS name that would normally have closed your flight plan.

B. ICAO Flight Plans
   i. As of June 2017, the FAA transitioned to the International Flight Plan Format for all VFR and IFR civil flights within the NAS (National Airspace System) and to Canada
   ii. Much of the information is identical to what would have been entered in an FAA Domestic flight plan. The biggest changes are in the Flight Rules, Type of Flight, Wake Turbulence Category, and the Aircraft Equipment Categories (this information comes from guidance developed by AOPA and the FAA and expected to be in the November 2017 AIM)
      a. Flight Rules
         - Flight rules are always required.
         - Flight rules should indicate:
            a I for IFR
            b V for VFR
            c 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 at this time. The IFR plan will be routed to ATC, and the VFR flight plan will be route to a Flight Service for Search and Rescue services.
               1. YFR (Y) will be for flights beginning under IFR flight rules followed by one or more changes in flight rules.
               2. ZFR (Z) will be for flights beginning under VFR flight rules, then followed by one or more changes in flight rules.
               3. For both YFR and ZFR, the point where the flight rules change will need to be noted in the route of flight. This point of change determines when the flight plan will be sent to ATC as appropriate.
      b. Type of Flight
         - Entering the type of flight is entirely optional for flights wholly within US Domestic Airspace
         - In the case that you do need to include the type of flight, indicate it as follows:
            a G - General Aviation
            b S - Scheduled Air Service

- c N - Non-Scheduled Air Transport Operation
- d M – Military
- e D - DVFR
- f X - other than any of the defined categories above

c. Wake Turbulence Category
- Include the wake turbulence category as follows:
  - a H - HEAVY, to indicate an aircraft type with a maximum 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, to indicate an aircraft type with a maximum certificated take-off mass of 15,500 lbs. or less

d. Aircraft Equipment
- Whereas the FAA Domestic flight plan used single letter designations to represent entire avionics packages (for example, G = RNAV capability with GNSS and without RVSM), the ICAO system lets the pilot pick and choose the equipment and capabilities specific to their aircraft.
- Equipment and capabilities that requires indication include:
  - a Navigation
  - b Transponder
  - c ADS-B
  - d Additional information may be required in the Remarks section for:
    1. PBN
    2. RVSM
    3. Data Communications
    4. More on this below
- 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.
  - a Aircraft Equipment
    1. Standard Capability (S)
       a. In order to simplify filing, the code “S” can be included to indicate Standard Capability, which includes VHF radio, VOR, and ILS
       b. The use of S removes the need to list these 3 capabilities separately
    2. No Capability (N)
       a. When there is no navigation, communications, or approach capability then file only the letter N
    3. More Capabilities

TBL 5-1-4

Aircraft COM, NAV, and Approach Equipment Qualifiers

INSERT one letter as follows:

N if no COM/NAV/approach aid equipment for the route to be flown is carried, or the equipment is unserviceable,

(OR)

S if standard COM/NAV/approach aid equipment for the route to be flown is carried and serviceable (see Note 1),

(AND/OR)

INSERT one or more of the following letters to indicate the COM/NAV/approach aid equipment available and serviceable:

NOTE–

The capabilities described below comprise the following elements:

a. Presence of relevant serviceable equipment on board the aircraft.

b. Equipment and capabilities commensurate with flight crew qualifications.

c. Where applicable, authorization from the appropriate authority.

A	GBAS landing system	J6	CPDLC FANS 1/A SATCOM (MTSAT)
B	LPV (APV with SBAS)	J7	CPDLC FANS 1/A SATCOM (Iridium)
C	LORAN C	L	ILS
D	DME	M1	ATC RTF SATCOM (INMARSAT)
E1	FMC WPR ACARS	M2	ATC RTF (MTSAT)
E2	D-FIS ACARS	M3	ATC RTF (Iridium)
E3	PDC ACARS	O	VOR
F	ADF	P1–P9	Reserved for RCP
G	(GNSS) – *see Note 2*	R	PBN approved - *see Note 4*
H	HF RTF	T	TACAN
I	Inertial navigation	U	UHF RTF
J1	CPDLC ATN VDL Mode 2 – *see Note 3*	V	VHF RTF
J2	CPDLC FANS 1/A HFDL	W	RVSM approved
J3	CPDLC FANS 1/A VDL Mode 4	X	MNPS approved/North Atlantic (NAT) High Level Airspace (HLA) approved
J4	CPDLC FANS 1/A VDL Mode 2	Y	VHF with 8.33 kHz channel spacing capability
J5	CPDLC FANS 1/A SATCOM (INMARSAT)	Z	Other equipment carried or other capabilities - *see Note 5*

NOTE–

1. *If the letter S is used, standard equipment is considered to be VHF RTF, VOR, and ILS within U.S. domestic airspace.*

2. *If the letter G is used, the types of external GNSS augmentation, if any, are specified in Item 18 following the indicator NAV/ and separated by a space.*

3. *See RTCA/EUROCAE Interoperability Requirements Standard For ATN Baseline 1 (ATN B1 INTEROP Standard – DO-280B/ED-110B) for data link services air traffic control clearance and information/air traffic control communications management/air traffic control microphone check.*

4. *If the letter R is used, the performance–based navigation levels that are authorized must be specified in Item 18 following the indicator PBN/. For further details, see Paragraph 5–1–9 b 8, Item 18 (c) and (d).*

5. *If the letter Z is used, specify in Item 18 the other equipment carried, preceded by COM/, DAT/, and/or NAV/, as appropriate.*

6. *Information on navigation capability is provided to ATC for clearance and routing purposes.*

b Transponder Capability

TBL 5–1–5

Aircraft Surveillance Equipment, Including Designators for Transponder, ADS–B, ADS–C, and Capabilities

INSERT N if no surveillance equipment for the route to be flown is carried, or the equipment is unserviceable, OR *INSERT* one or more of the following descriptors, to a maximum of 20 characters, to describe the serviceable surveillance equipment and/or capabilities on board:	
SSR Modes A and C	
A	Transponder - Mode A (4 digits – 4096 codes)
C	Transponder - Mode A (4 digits – 4096 codes) and Mode C
SSR Mode S	
E	Transponder - Mode S, including aircraft identification, pressure-altitude and extended squitter (ADS-B) capability
H	Transponder - Mode S, including aircraft identification, pressure-altitude and enhanced surveillance capability
I	Transponder - Mode S, including aircraft identification, but no pressure-altitude capability
L	Transponder - Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS B) and enhanced surveillance capability
P	Transponder - Mode S, including pressure-altitude, but no aircraft identification capability
S	Transponder - Mode S, including both pressure-altitude and aircraft identification capability
X	Transponder - Mode S with neither aircraft identification nor pressure-altitude capability
NOTE– *Enhanced surveillance capability is the ability of the aircraft to down-link aircraft derived data via a Mode S transponder.*	
Followed by one or more of the following codes if the aircraft has ADS-B capability:	
B1	ADS-B with dedicated 1090 MHz ADS-B "out" capability
B2	ADS-B with dedicated 1090 MHz ADS-B "out" and "in" capability
U1	ADS-B "out" capability using UAT
U2	ADS-B "out" and "in" capability using UAT
V1	ADS-B "out" capability using VDL Mode 4
V2	ADS-B "out" and "in" capability using VDL Mode 4
NOTE– *File no more than one code for each type of capability; for example, file B1 or B2,but not both.*	
Followed by one or more of the following codes if the aircraft has ADS-C capability:	
D1	ADS-C with FANS 1/A capabilities
G1	ADS-C with ATN capabilities

EXAMPLE–

1. *SDGW/SB1U1 {VOR, ILS, VHF, DME, GNSS, RVSM, Mode S transponder, ADS-B 1090 Extended Squitter out, ADS-B UAT out}*

2. *S/C {VOR, ILS, VHF, Mode C transponder}*

- Example
  - a If your aircraft had:
    1. A VHF Radio, VOR and ILS — S
    2. An IFR approved GPS — G
    3. PBN Capable — R
       a. If you are able to 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.
    4. Mode C Transponder — C
  - b The final entry into Box 10 would be SGR/C

- 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.
    1. The majority of general aviation piston aircraft will enter: PBN/B2C2D2
        a. B2= RNAV 5 capability, C2 = RNAV 2 capability, D2 = RNAV 1 capability
        b. By listing this code, you are telling ATC you are capable of handling RNAV based procedures for the en route structure and terminal procedures.

iii. For more information:
   a. A great, short ICAO flight plan instructional video from AOPA
   b. ICAO Flight Plan instructions expected to be included in the 2017 AIM
   c. FAA Aircraft Type Designators
   d. ICAO Flight Plan Form
   e. AIM 5-1-9 – International Flight Plan - IFR Flights

5. Activating and Closing a VFR Flight Plan

A. Filing a flight plan isn't required but it is a good operating practice since the information can be used for search and rescue in the case of an emergency

B. Filing can be done on the ground or in the air
   i. On the ground: Call the FSS (1 800-WX BRIEF) or use DUAT
      a. After takeoff, contact the FSS by radio and give them the takeoff time to activate the flight plan
         - FSS frequencies can be found on a sectional
      b. Once filed, the flight plan will be held for an hour after the proposed departure time

C. Activating a Flight Plan
   i. With an FSS
      a. Contact an FSS after takeoff and inform them you'd like to open your flight plan on file
         - If you are using flight following and only have 1 radio, ask to leave the frequency to activate your flight plan
      b. Provide them your call sign and time of departure
   ii. With Tower
      a. At a location with an active, tower, the aircraft identification will be forwarded by the tower to the FSS for reporting the actual time of departure
         - This procedure should be avoided at busy airports

D. Don't forget to close the flight plan
   i. Close a VFR flight plan with an FSS or by calling 1-800 WX BRIEF
   ii. The FAA will institute a search 30 min after the scheduled arrival time if the flight plan is not closed

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. The Pilot

A. IMSAFE – The pilot's preflight checklist:
   i. Illness – Do you feel well?
   ii. Medication – Are you taking anything that could or should prevent you from flying
   iii. Stress – Are you over stressed, or preoccupied? Should you avoid flying?
   iv. Alcohol – Have you been drinking or are you hung over?
   v. Fatigue – Are you well rested?

vi. Eating – Are you properly nourished?
vii. There are a few different IMSAFE acronyms, for example the E can also be Emotion – Is there something in your life that should prevent you from flying?
    a. The idea remains the same: is there anything physical, mental or emotional that should prevent you from taking this flight?

2. The Aircraft
- A. Is the aircraft in a safe condition for flight?
- B. Never take an aircraft you aren't comfortable with
    - i. If there is an issue you aren't comfortable with, have it fixed
- C. Perform a thorough, proper preflight inspection, and engine run up prior to takeoff

3. The Environment
- A. Weather
    - i. Have a full understanding of the weather at your departure, en route and at the destination
        - a. Make a competent, rational Go/No Go Decision
- B. Airports
    - i. Review all potential airports (departure, destination, alternates)
    - ii. Be aware of their layout, capabilities (fuel, parking, runways, etc.), procedures, etc.
- C. Airspace
    - i. Review a sectional and be familiar with the airspace the route of flight will take you through and the requirements associated with that airspace
    - ii. Avoid areas if necessary (restricted, TFRs, etc.)
- D. Terrain
    - i. Study the terrain en route. Ensure the aircraft is capable of transitioning the terrain based on the expected conditions (weather and aircraft, aircraft weight, fuel, etc.)
    - ii. Ensure the altitude selected to fly compensates for the terrain and provides the ability to glide to safety in the case of an emergency
- E. Obstacles
    - i. Study the route and airports for obstacles that may be of concern during all phases of flight. Be aware of procedures specific to airports due to obstacles (for example, traffic pattern direction to avoid a mountain)

4. External Pressures
- A. External pressures should have no part in the decision-making process
- B. An unsafe situation is not acceptable because you "need" to get somewhere by a certain time

5. Limitations of ATC Services
- A. VFR flight following is an excellent tool and can greatly enhance your safety and situational awareness, but the controller can decline your request if he or she is too busy with IFR traffic
    - i. Flight following is also dependent on radar
        - a. Radar services can get lost at low altitudes
        - b. Radar services do not cover the entire US, therefore certain areas may not have radar coverage and therefore no flight following
- B. Radio Coverage
    - i. Just like radar coverage, radio communication may be lacking in certain areas and at certain altitudes
- C. Although tower can forward your departure time and tail to an FSS, this may not happen at busy airports and you will have to contact the FSS on your own

6. Improper Fuel Planning
- A. Use the POH, be conservative, and always have alternates en route

B. Your nav log will have the expected fuel at each waypoint, monitor the fuel burn to ensure you are burning what you expected.
    i. If the aircraft is burning more than planned and a low fuel situation may arise, make a decision early. Land, and get more gas (if you already have an en route alternate planned, this almost becomes a non-issue)
C. Plan Ahead! (not only with fuel, but with emergency en route alternates)

ADDITIONAL INFORMATION NOT INCLUDED IN THE ACS REQUIREMENTS:

1. **Terms**
    A. Navigation Terminology
        i. True Course – The direction of flight as measured on a chart clockwise from true North
        ii. 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
        iii. Magnetic Course – True course corrected for magnetic variation
        iv. Magnetic Heading – Magnetic Course corrected for wind (direction and speed)
        v. Compass Heading – Aircraft heading read from the compass
            a. Derived by applying correction factors for variation, deviation, and wind to your true course
        vi. 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
        vii. Variation – The angular difference between true north and magnetic north; isogonic lines on charts
    B. Atmospheric Terminology
        i. Standard Pressure – 29.92" Hg (at sea level)
        ii. Standard Temperature – 15° C/59°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 - $120(℃ - 15℃) + PA$
            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 particular 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. **Pilotage and Dead Reckoning**
    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 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, 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. Except for flights over water, dead reckoning is usually used with pilotage
   i. Heading and GS is constantly monitored and corrected by pilotage as observed from checkpoints
   ii. Ideally, Radio navigation should be added so that a pilot uses all three forms of navigation
      a. Start with dead reckoning and confirm with pilotage and radio navigation

3. Weather Check

A. Obtaining a preflight weather briefing is the first step to determine if the flight can be conducted safely
   i. 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. Go/No Go
   i. Good judgment is necessary in deciding whether or not to take the flight
      a. A gutsy, dangerous condition could end badly
   ii. Weather factors must be considered in relation to the equipment to be flown
      a. Can the aircraft handle the flight?
         - Are any limitations exceeded
      b. The following conditions may lead to a No-Go Decision
         - T-Storms of any kind, especially embedded
         - Fast-moving fronts or squall lines
         - Moderate or greater turbulence
         - Icing
         - Fog, or other visual obscurations
         - Excessive wind
   iii. Physical/Mental condition
      a. Sick, tired, upset, depressed – These factors can greatly affect the ability to handle any problem
      b. IMSAFE checklist
   iv. Recent Flight Experience
      a. Don't go beyond your abilities or the airplane's abilities
      b. EX: Are you comfortable in MVFR if you haven't flown in a while

4. Diversion to an Alternate

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, pilot/passenger fatigue/illness, etc.

B. Before flight, check the route for suitable landing areas and for navaids 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 to determine the approximate new heading

D. Choose an alternate shown on your sectional or use the 'Nearest' page in the GPS

E. Procedure
  i. Confirm your present 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, etc.

5. Lost Procedures

A. Avoiding Becoming Lost
  i. Always know where you are - Plan ahead, Know the next landmark/Anticipate Nav indications
  ii. If the radio nav systems/visual observations do not confirm expectations, take corrective actions
  iii. Use multiple landmarks to verify your position
    a. If possible don't depend on one landmark

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 with 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

SKILLS

The applicant demonstrates the ability to:

1. Prepare, present and explain a cross-country flight plan assigned by the evaluator including a risk analysis based on real-time weather, to the first fuel stop.
2. Apply pertinent information from appropriate and current aeronautical charts, chart supplements; NOTAMs relative to airport, runway and taxiway closures; and other flight publications.
3. Create a navigation plan and simulate filing a VFR flight plan.
4. Recalculate fuel reserves based on a scenario provided by the evaluator

I.E. National Airspace System

References: 14 CFR Parts 71, 91, 93, Risk Management Handbook (FAA-H-8083-2), AIM, Navigation Charts

KNOWLEDGE

The applicant demonstrates understanding of:

1. Types of Airspace and VFR Weather Minimums

A. Class E Airspace
  i. Definition
    a. Controlled airspace that is not designated A, B, C, or D
    b. Where the majority of your flying time will be
  ii. Operating Rules and Pilot/Equipment Requirements
    a. Previously established rules apply:
      - Transponder Requirements (91.215(d))
        a At or above 10,000’ MSL
          1. Excluding airspace below 2,500’ AGL
        b Within 30 miles of a class B airspace primary airport, below 10,000’ MSL
        c Within and above all Class C airspace, up to 10,000’ MSL
        d Within 10 miles of certain designated airports
          1. Excluding airspace which is both outside the Class D surface area and below 1,200’ AGL
        e Flying into, within, or across the ADIZ
      - Airspeeds (91.117)
        a No more than 250 knots below 10,000’ MSL
        b Below 2,500’ AGL within 4 nm of the primary class C, D airspace not over 200 knots
        c Underlying Class B airspace designated for an airport or in a VFR corridor designated through class B airspace not over 200 knots
    b. Pilot Qualifications: Student Pilot

Airspace Features	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	None
ATC Services	IFR/IFR Separation VFR advisories on request (permitting)

  iii. 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
  iv. 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 upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace
  v. 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, they extend upward 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 en route environment

c. When needed for IFR control purposes
- En Route Domestic Areas
  - a Provide controlled airspace in those areas where there is a requirement to provide IFR en route ATC services but the Federal Airway System is inadequate
  - b Airspace areas that extend upward from a specified altitude as an en route 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, extends from the surface to 2,500 feet above the 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. The configuration of Class D airspace is configured to meet the operational needs/instrument procedures of the area

Airspace Features	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

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

C. Class C Airspace

i. Definition
   a. Generally, extends from the surface to 4,000 feet above the airport elevation
   b. These airports have an operational control tower and are serviced by a radar approach control, and with a certain number of IFR operations or passenger enplanements
   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

Airspace Features	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
ATC Services	IFR/IFR & VFR Separation VFR Traffic advisories (permitting)

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 ATC prior to entering the airspace
      - Operable radar beacon transponder with automatic altitude reporting equipment (Mode C)

D. Class B Airspace
i. Definition
   a. Generally, the airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports (IFR traffic)
   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 once entered
ii. Operating Rules and Pilot/Equipment Requirements
   a. For VFR Operations:
      - At least a Private Pilot Certificate is required
         a Exception: student/recreational pilots seeking private pilot certification with an endorsement (CFR 61.95)
      - 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
      - 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 Aircraft operating in this airspace must be equipped with automatic pressure altitude reporting equipment having Mode C capability
   b. For IFR operations:
      - An operable VOR or TACAN receiver

Airspace Features	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
ATC Services	All Aircraft Separation

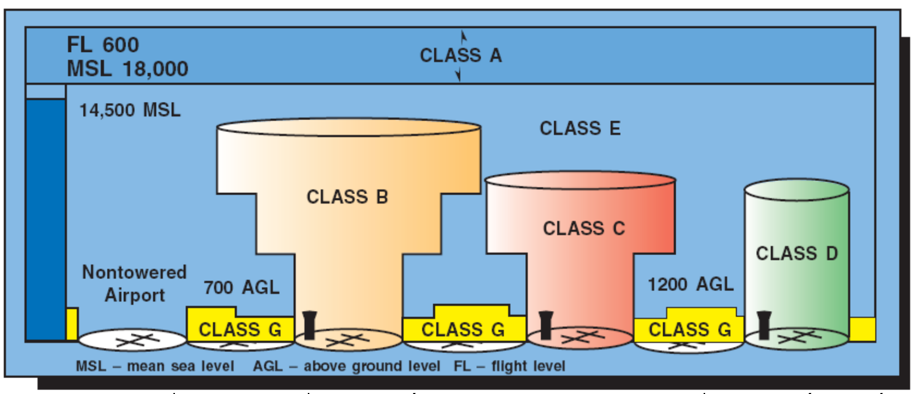
Airspace Features	Class G

- An operable radar beacon transponder with automatic altitude reporting equipment

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. Unless otherwise authorized, all operation in Class A airspace will be conducted under IFR

F. Class G Airspace
   i. Definition
      a. Uncontrolled Airspace
      b. The portion of airspace that has not been designated as Class A, B, C, D, or E
   ii. Extends from the surface to the base of the overlying Class E airspace
   iii. Although ATC has no authority/responsibility to control air traffic here, there are VFR minimums which apply to Class G airspace

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)



		...ent	Minimum Pilot Certificate
			Instrument Rating
		...ansponder ...rting	Private – with exception
	prior to entry	...ansponder with Altitude reporting capability	No specific requirement
D	Two-way radio communications prior to entry	Two-way radio	No specific requirement
E	None for VFR	No specific requirement	No specific requirement
G	None	No specific requirement	No specific requirement

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. **Charting Symbology**
   A. FAA Aeronautical Chart User's Guide
3. **Special Use Airspace**
   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 purposes associated with the national welfare
      iii. Published in the Federal Register and are depicted on aeronautical charts
   B. Restricted Areas
      i. Airspace within which the flight of aircraft, while not wholly prohibited, is subject to restrictions
      ii. Denote the existence of unusual, often invisible hazards to aircraft
         a. Such as artillery firing, aerial gunnery, or guided missiles
      iii. An aircraft may not enter a restricted area unless permission has been obtained from the controlling agency
         a. If it is not active, ATC will allow the aircraft to operate in the airspace
         b. If it is active, ATC will ensure the aircraft avoids the restricted area (on an IFR flight plan)
      iv. Restricted areas are depicted on aeronautical charts and are published in the Federal Register
   C. Warning Areas

    i. Airspace extending from 3 nm outward from the coast of the US, 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 established for the purpose of separating certain military training activity from IFR traffic
    ii. IFR traffic may be cleared through a MOA if IFR separation can be provided by ATC, otherwise ATC will reroute the traffic
    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
    ii. They are depicted on aeronautical charts
  F. Controlled Firing Areas
    i. Contain activities, which, if not conducted in a controlled environment, could be hazardous to nonparticipating aircraft
    ii. Activities here must be suspended when a spotter aircraft, radar, or ground lookout position indicates 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. Special Flight Rules Area
  A. A region in which the normal regulations of flight do not apply in whole or in part, especially regulations concerning airspace classification, altitude, course, and speed restrictions, and the like.
    i. Examples include Washington D.C., Los Angeles, Hudson River, the Grand Canyon, etc.
    ii. Be familiar with the specific procedures and requirements for navigating each SFRA you intend to transition
        a. Instructions for the Los Angeles SFRA, for example, are located on the LA terminal area chart

5. Temporary Flight Restrictions (TFRs)
  A. An FDC NOTAM will be issued to designate a TFR
    i. 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
    ii. The NOTAM will also contain the FAA coordination facility and telephone number, the reason for the restriction, and any other information deemed appropriate
  B. Purposes for establishing a TFR:
    i. Protect persons and property in the air or on the surface from an existing or imminent hazard
    ii. Provide a safe environment for the operation of disaster relief aircraft
    iii. Prevent an unsafe congestion of sightseeing aircraft above an incident or event, which may generate a high degree of public interest
    iv. Protect declared national disasters for humanitarian reasons in Hawaii
    v. Protect the President, VP, or other public figures
    vi. Provide a safe environment for space agency operations
  C. It is very important to check these before flying
    i. Not only could it be dangerous to yourself and others to fly through a TFR, but you run the risk of discipline

6. Other Airspace Areas

A. Local Airport Advisory (LAA) Areas
   i. An area within 10 SM of an airport where a control tower is not operating, but where a FSS is located
   ii. At these locations, the FSS provides advisory service to arriving and departing aircraft
B. Military Training Routes
   i. Used by military aircraft to maintain proficiency in tactical flying
   ii. Usually below 10,000’ MSL for operations at speeds in excess of 250 knots
   iii. Shown on sectionals, designated by IR or VR and followed by a number
      a. IR is IFR, VR is VFR
      b. A route with a 4-number identifier has no segment above 1,500’ AGL
      c. A route with a 3-number identifier includes 1 or more segments above 1,500’ AGL
C. Parachute Jump Areas
   i. Published in the AFD
   ii. Frequently used sites are depicted on sectional charts
D. 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
E. 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 en route terminal environment
   iv. TRSAs are depicted on VFR sectional charts and 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
F. 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

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Various classes and types of airspace
   A. Plot your route on a map and thoroughly review the airspace you will transition
   B. Ensure you understand and meet the requirements to transition all airspace planned
   C. If possible, avoid special use airspace
      i. If unable ensure you understand the risks and permissions required to use it
   D. Use VFR flight following to provide an extra set of eyes to help avoid special use airspace or to confirm whether areas are hot or cold (EX: MOA’s or restricted areas)

   i. VFR flight following can also warn you (and the other aircraft using the airspace) of potential conflicts

SKILLS

The applicant demonstrates the ability to:

1. Explain the requirements for basic VFR weather minimums and flying in particular classes of airspace.
2. Correctly identify airspace and operate in accordance with associated communication and equipment requirements.
3. Explain the requirements for operating in a SUA or within a TFR. Explain SATR and SFRA operations, if applicable.

I.F. Performance and Limitations

References: Weight and Balance Handbook (FAA-H-8083-1), Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Preflight Action Requirements** (this is not part of the ACS, but it is applicable and important to this section)
   A. FAR 91.103: Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information must include:
      i. For a flight under IFR or a flight not in the vicinity of an airport, weather reports and forecasts, fuel requirements, alternatives available if the planned flight cannot be completed, and any known traffic delays of which the pilot in command has been advised by ATC;
      ii. For any flight, runway lengths at airports of intended use, and the following takeoff and landing distance information:
         a. For civil aircraft for which an approved Airplane or Rotorcraft Flight Manual containing takeoff and landing distance data is required, the takeoff and landing distance data contained therein; and
2. **Performance and Limitations Charts**
   A. Airplane performance is found in Section 5 of the POH (Performance and Limitations)
      i. Supplement 4, for the DA20 (any charts not shown in the supplement are found in Chapter 5)
   B. Using the performance charts, and the accompanying instructions, we can calculate
      i. Cruise Performance
      ii. Stall Speeds based on airplane configuration
      iii. Wind Components (Crosswind and Headwind)
      iv. Takeoff Distance and Landing Distance
      v. Climb Performance (In cruise and takeoff configurations as well as Balked Landing)
      vi. True Airspeed
      vii. Maximum Flight Duration (Chart in which the Pressure Altitude is combined with RPM to find % bhp, KTAS, GPH)
   C. In order to make use of these charts we need to know the Pressure Altitude (PA)
      i. Pressure Altitude – The altitude indicated when the altimeter setting window is set to 29.92
         a. PA = 1,000(29.92-Current Altimeter Setting) + Elevation
            - EX: Altimeter = 30.42 and Elevation = 808, so PA = 308'
            - EX: Altimeter = 29.84 and Elevation = 808, so PA = 888'
      ii. From Pressure Altitude we can compute Density Altitude (DA)
         a. DA: Pressure Altitude corrected for non-standard temperature (Directly related to airplane performance)
         b. DA = 120(Current Temperature-15°C) + PA
            - EX: Temp = 23°C and PA = 308', so DA = 1,268'
            - EX: Temp = 03°C and PA = 308', so DA = -1,132
            - This is a good estimate of DA, the equation is not perfect
   D. Using the Charts (This is tailored to the Diamond 20 Performance Charts)
      i. Using the Pressure Altitude, start at the temperature at the bottom of the chart and move up to the PA
         a. From there, move straight across until reaching the next stage of the chart

- Once you reach the next step, mirror the trend line and then move straight across to the next stage of the chart

ii. This is done until we reach the performance number

E. How the Charts Work

i. The charts take into account the various factors that affect the performance criteria you're trying to obtain

a. EX: On takeoff, the chart requires, the temperature, pressure altitude, weight, wind (head or tailwind), etc.

ii. The charts also represent how each factor affects the performance criteria

a. EX: For takeoff, a headwind will decrease the amount of runway required, and a tailwind will increase the amount of runway required for takeoff

3. Factors Affecting Performance

A. Atmospheric Conditions

i. General

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 approximately 14.7 pounds per square inch

c. Since air is a gas, it can be compressed or expanded

d. The density of the air has significant effects on the airplane's performance

- As the density of the air increases (high air pressure), airplane performance increases and vice versa

ii. What Changes Air Density?

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 In simple terms, the reason for this is that Oxygen molecules (O_2) are being replaced with water molecules (H_2O). Hydrogen is considerably lighter than oxygen. By replacing oxygen with hydrogen, the density 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
    - a Power is produced in proportion to air density (As density increases, power does too)
- Thrust since the propeller is less effective in thin air
    - a Thrust is produced in proportion to the mass of air being accelerated, less dense air means less air being accelerated
- Lift because the thin air exerts less force on the airfoils
    - a As air density decreases, the lift efficiency of the wing is decreased

iv. Leaning the Engine

a. At power settings less than 75% or at Density Altitudes > 5,000' the engine must be leaned for max power on takeoff

- An excessively rich mixture deters engine performance
- Less dense air needs less fuel

   b. At higher elevations, high temperatures may have such an effect on density altitude that safe operations may not be possible
      - Even at lower temperatures with excessive humidity, performance can be marginal and weight may need to be reduced

B. Pilot Technique
   i. Different techniques can change aircraft performance
      a. EX: Climbing at speeds other than what is recommended in the POH
         - This negates any climb performance data you may have calculated from the charts
   ii. A simple way to fix this is to fly by the book – the charts are designed based on specific aircraft configurations and speeds; fly those!

C. Aircraft Configuration
   i. The configuration of the aircraft can have a large effect on performance
      a. Gear, whether retracted or extended, can significantly influence drag
      b. Flaps increase lift but also increase drag. Different flap settings may have larger effects on lift and/or drag influencing the aircraft's performance
      c. Use the charts and information in the POH to determine the aircraft's performance capabilities in various configurations

D. Airport Environment
   i. Different airport environments can affect the performance of the aircraft in various ways
      a. Inclined or declined runways can adjust takeoff and landing distance
      b. Hills, mountains, trees, buildings, etc. can affect wind patterns creating changing winds and at times up or down drafts
      c. High altitude airports greatly decrease performance
         - Also, at high altitudes, true airspeed is increased. Even though you're flying an approach at a normal indicated airspeed, you are moving much faster than you would be at sea level. This greatly affects landing distances

E. Effects of Loading on Performance
   i. Weight and Flight Performance
      a. A heavier gross weight will result in:
         - Higher takeoff speed, longer takeoff run, reduced rate and angle of climb, lower maximum altitude, shorter range, reduced cruise speed, reduced maneuverability, higher stall speed, higher approach and landing, longer landing roll, excessive weight on the nose or tail wheel
         - Climb and cruise performance is reduced which can lead to:
            a Overheating in climbs, added wear on engine, and increased fuel use
   ii. Weight and Structure
      a. Structural failures which result from overloading may be catastrophic but they often affect structure progressively making it difficult to detect or repair
      b. An airplane is certified to withstand certain loads on its structure based on the category
         - As long as gross weight and load factors limits are observed, the total load will remain in limits
         - If the max gross weight is exceeded, load factors within the load factor limits can cause damage
      c. The results of routine overloading are cumulative and may result in failure later during normal ops

F. Effects of Weight and Balance
   i. A stable and controllable plane may have very different characteristics when overloaded
      a. Weight distribution has the most effect, but gross weight also adversely affects stability

ii. An airplane with forward loading
    a. The aircraft acts heavier than it actually is, and consequently slower than the same airplane with a further aft center of gravity
        - Nose up trim is needed which requires the tail surfaces to produce a greater down force. This adds to the wing loading, increasing the total lift required from the wings
    b. Requires a higher angle of attack, which results in more drag and, in turn, produces a higher stalling speed
    c. The airplane is more controllable (the longer arm from the CG makes the elevator more effective) – More below in Part E
iii. An airplane with aft loading
    a. With aft loading, the aircraft acts lighter than it actually is
    b. The aircraft requires less nose down force allowing for a faster cruise speed
        - Faster cruise because of the reduced drag (smaller angle of attack and less down deflection of stabilizer)
        - The tail surface is producing less down force, relieving the wing of loading and lift which results in a lower stall speed
            a Although the stall speed is lower, recovery from a stall becomes progressively more difficult as the center of gravity moves aft
iv. The CG and the Lateral Axis
    a. Unbalanced lateral loading (more weight on the right or left side of the aircraft centerline) may result in adverse effects
        - This can be caused by: fuel imbalance, people, baggage, etc.
    b. Compensate for any imbalance with trim (if available), or constant control pressure
        - This places the aircraft in an out-of-streamline condition, increasing drag, and decreasing efficiency
v. Weight and Controllability
    a. Generally, an airplane becomes less controllable as the center of gravity moves aft
        - The elevator has a shorter arm and requires greater deflection for the same result
        - Stall recovery is more difficult because the plane's tendency to pitch down is reduced
            a If the center of gravity moves beyond the aft limit, stall and spin recovery may become impossible
    b. As the center of gravity moves forward, the airplane becomes more nose-heavy
        - Although the aircraft is more controllable, since the arm between the center of gravity and elevator is larger, the aircraft may become so nose heavy that the elevator may not be able to hold up the nose, particularly at low airspeeds (takeoff, landing, glides)
            a On landing the elevator may not be able to produce sufficient force to lift the nose wheel during the flare, in extreme cases a safe landing could be impossible

G. Effects of Weight and Balance over the course of the Flight
    i. During the flight the weight and balance of the aircraft will change based on any weight that is moved or lost
        a. The most common example is the en route fuel burn
            - As fuel is burned, weight is lost in the fuel tanks and the center of gravity will change
                a Whether it moves forward or backward depends on the aircraft you're flying and the location of the fuel tanks
            - In order to compensate for the changing fuel, calculate the center of gravity at the fuel level for departure, and calculate the center of gravity with empty tanks

        a If the center of gravity stays within limits throughout the transition from full (or departure level) tanks to empty tanks, there will be no center of gravity problem en route
    b. If for any reason the weight or balance will change en route (EX: passengers, baggage, fuel etc.) ensure the center of gravity remains within limits in order to preclude a potential loading emergency in flight

4. Aerodynamics

A. Airfoil Design Characteristics
  i. Planform is the term that describes the wings outline as seen from above
    a. 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.
    b. There are many different shapes and advantages/disadvantages to each (many shapes are combined)
  ii. Taper – The ratio of the root chord to the tip chord
    a. Rectangular wings have a taper ratio of 1
      - Simpler and more economical to produce and repair (ribs are same size)
      - The root stalls first providing more warning and control during recovery
    b. Ellipse (Tapered)
      - Provides the best span wise load distribution and lowest induced drag
      - But, the whole wing stalls at the same time and they are very expensive/complex to build
  iii. Aspect Ratio – divide the wingspan by the average chord
    a. The greater the aspect ratio, the less induced drag (more lift)
    b. Increasing wingspan (with the same area) results in smaller wingtips, generating smaller vortices
      - Reduces induced drag and are more efficient
      - Planes requiring extreme maneuverability and strength have much lower aspect ratios
        a Ex: Fighter, and aerobatic aircraft
  iv. Sweep – When the line connecting the 25% chord points of the ribs isn't perpendicular to the longitudinal axis
    a. The sweep can be forward, but it is usually backward
    b. Help in flying near the speed of sound but also contributes to lateral stability in low-speed planes

B. Airplane Stability and Controllability
  i. Controllability - Capability to respond to the pilot's control especially in regard to flight path and attitude
    a. Quality of response to control application when maneuvering regardless of stability characteristics
  ii. Maneuverability - Quality that permits a plane to be maneuvered easily and withstand stresses imposed
    a. Governed by the weight, inertia, size/location of flight controls, structural strength and power plant
    b. It is a design characteristic
  iii. Stability
    a. The inherent quality of an airplane to correct for conditions that may disturb its equilibrium, and return to or continue on the original flight path (This tendency is primarily a design characteristic)
      - In other words, a stable plane will tend to return to its original condition if disturbed

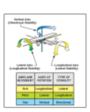
        a The more stability, the easier to fly, but too much results in significant effort to maneuver
            1. Therefore, stability and maneuverability must be balanced

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

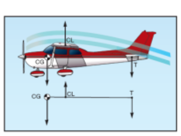
c. Static Stability (SS)
    - Equilibrium: All opposing forces are balanced (Steady un-accelerated flight conditions)
    - SS: The *initial tendency* that airplane displays after its equilibrium is disturbed
        a Positive SS: The initial tendency to return to the original state of equilibrium after being disturbed (to return to the trimmed condition)
        b 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)
        c 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)
    - Positive SS is the most desirable - The plane attempts to return to the original trimmed attitude

d. Dynamic Stability (DS)
    - SS refers to the initial response, DS describes how the system responds over time
        a Refers to whether the disturbed system returns to equilibrium over time or not
        b The degree of stability can be gauged in terms of how quickly it returns to equilibrium
        c Referred to as Positive, Negative, and Neutral – Same as SS but over time (overall tendency)
    - DS can be further divided into oscillatory and non-oscillatory modes
        a Oscillatory: Smooth bowl with a marble on the bottom – the system is in equilibrium
            1. If moved up the side and let go (disturb equilibrium) it comes to rest after some oscillations
                a. Positive static, and oscillatory positive dynamic stability
            2. The longer oscillations (time), the easier the plane is to control (long period > 10 sec)
            3. The shorter oscillations, the more difficult, to control (short period < 1-2 sec)
            4. Neutral/Divergent short oscillation is dangerous as structural failure can result
        b Non-Oscillatory: Do the same thing with a cotton ball, it simply returns with no oscillations
    - Most desirable is Positive Dynamic Stability

e. Longitudinal Stability (LS)



    - LS makes an airplane stable about its lateral axis and involves the pitching motion
        a A Longitudinally unstable plane has a tendency to dive and climb progressively steeper making it difficult/dangerous to fly
    - To obtain LS the relation of the wing and tail moments must be such that, if the moments are initially 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
    - Static LS or instability is dependent on 3 factors:



        a Location of the wing in relation to the Center of Gravity (CG)
            1. The CG is usually ahead of the wing's Center of Lift (CL) resulting in nose down pitch

2. 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)
3. 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; the Tail down force is weaker (but has a longer arm)
4. 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 diminish until the aircraft returns to stabilized flight.

b Location of the horizontal tail surfaces with respect the CG
1. 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
        i. Any small disturbances are opposed by larger forces, dampening them quickly
2. 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 an 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
1. The larger the area/size of the tail surface, the more force exerted

f. Lateral Stability (About the Longitudinal Axis)
- Lateral stability about the longitudinal axis is affected by:
    a Dihedral; Sweepback Angles; Keel Effect; Weight Distribution
- Dihedral is the angle at which the wings are slanted upward from the root to the tip
    a Dihedral balances lift created by the wings' AOA on each side of the longitudinal axis
        1. The airplane tends to sideslip or slide downward toward the lowered wing
        2. Dihedral causes the air to strike the low wing at a greater AOA than the high wing
        3. This increases the low wing lift/decreases high wing lift restoring the original attitude
    b Shallow turn: the increased AOA increases lift on the low wing with a tendency to return the aircraft to Straight and Level flight
- Sweepback is the angle at which the wings are slanted rearward from the root tip
    a Sweepback increases dihedral to achieve stability, but the effect is not as pronounced
- 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

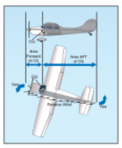
1. When the plane slips to one side, the combo of the plane's weight and the pressure of the airflow against the upper portion of the keel area rolls the plane back to wings level

b To Summarize: The fuselage is forced by keel effect to parallel the wind

- Weight Distribution
  - a If more weight is located on one side, it will have a tendency to bank that direction

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

- 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
- SIDE - For a weathervane to work, a greater surface area must be aft of the pivot point
  - a Therefore, the side surface must be greater aft of the CG than ahead of the CG
  - 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



- VERTICAL FIN – the vertical fin acts like a feather on an arrow in maintaining straight flight
  - 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
    1. This puts pressure on vertical fin stopping the motion and then returning the nose into the relative wind (like a weathervane)
    2. Ex: If the nose yaws right, the relative wind puts pressure on the left side of the vertical stabilizer stopping the movement and moving the nose of the aircraft back to the left

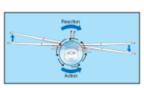
C. Turning Tendency (Torque Effect – Left Turning Tendency)

i. Torque is made up of 4 elements which produce a twisting axis around at least 1 of the planes 3 axes

a. Torque Reaction, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Prop, and P-Factor

ii. Torque Reaction

a. Newton's 3rd Law – For every action there is an equal and opposite reaction



- The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction

b. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency

c. On the ground, during takeoff, the left side is being forced down resulting in more ground friction

- This causes a turning moment to the left that is corrected with rudder
  - a Strength is dependent on engine size/hp, propeller size/rpm, plane size and ground surface
    1. The higher the power setting, the greater the left turning tendency

d. Torque is corrected by offsetting the engine, and using aileron trim tabs, and aileron/rudder use

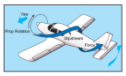
- Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset in order to counteract a portion of the rolling motion caused by torque
- Trim tabs can be adjusted to counter the turning tendency in level flight
- Torque not countered by the engine and trim tab position must be corrected with coordinate rudder and aileron inputs

iii. Corkscrew/Slipstream Effect

a. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft

- The air strikes the left side of the vertical stabilizer, pushing the nose of aircraft left

b. At high prop speeds/low forward speeds the rotation is very compact



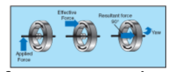
- This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
- The corkscrew flow also creates a rolling moment around the longitudinal axis
    - a The rolling moment is to the right and may counteract torque to an extent

c. As the forward speed increases, the spiral elongates and becomes less effective

d. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in climbs (high prop speed and low forward speed)

iv. Gyroscopic Action

a. Gyroscopes are based on two fundamental principles:

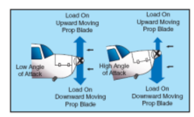


- Rigidity in space (not applicable to this discussion)
- Precession - The resultant action of a spinning rotor when a force is applied to its rim
    - a If a force is applied, it takes effect 90º ahead of, and in the direction of turn
        1. This causes a pitch/yaw moment or combo of the two depending on where applied
        2. Ex: This most often occurs with tail wheel aircraft when the tail is being 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
                i. This force is felt 90º in the direction of rotation (clockwise as viewed from the cockpit)
            b. The forward force will take effect on the Right side of the propeller, yawing the aircraft Left

b. Any yawing around the vertical axis results in a pitching moment

c. Any pitching around the lateral axis results in a yawing moment

d. Correction is made with necessary elevator and rudder pressures



v. Asymmetric Loading (P Factor)

a. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade

- This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)

b. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc

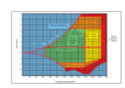
- At positive AOA, the R blade is passing through an area of resultant velocity greater than the L
- Since the prop is an airfoil, increased velocity means increased lift
    - a Therefore, the down blade has more lift and tends to yaw the plane to the left

c. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)

- If there were no air movement at all, except that generated by the prop, identical sections of the blade would have the same airspeed
- 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
    - a The blade proceeding is creating more lift or thrust, moving the center of lift toward it
- Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
    - a The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow

d. Summary: The descending blade of the propeller 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 the aircraft will have a tendency to yaw to the left

D. Load Factors (LF) in Airplane Design
  i. LF – The force applied to an aircraft to deflect its flight from a straight line that produces a stress on its structure
    a. Load factor is the ratio of the total air load acting on the airplane to the gross weight of the airplane
      - EX: a LF of 3 means that total load on the structure is 3x its gross weight; expressed as 3 G's
        a Subjecting a plane to 3 G's will result in being pressed into the seat by 3x your weight
  ii. LF is important to the pilot for two distinct reasons
    a. The obviously dangerous overload that is possible for a pilot to impose on the structure
      - An excessive load can result in the structural failure of an aircraft
    b. An increased LF increases the stall speed and makes stalls possible at seemingly safe speeds
  iii. Airplane Design
    a. How strong an airplane should be is determine largely by the use it will be subjected to
      - This is difficult as maximum possible loads are much too high to incorporate in efficient design
        a If planes are to be built efficiently, extremely excessive loads must be dismissed
        b The problem becomes determining the highest LF that can be expected in normal operation under various operational situations – These are 'Limit Load Factors'
          1. Planes must be designed to withstand Limit Load Factors with no structural damage
    b. Airplanes are designed in accordance with the Category System:
      - Normal Category limit load factors are -1.52 G's to 3.8 G's
      - Utility Category limit load factors are -1.76 G's to 4.4 G's (Mild acrobatics, spins)
      - Acrobatic Category limit load factors are -3.0 G's to 6.0 G's
    c. The more severe the maneuvers, the high the load factors
  iv. The Vg diagram shows the flight operating strength of a plane that is valid for a certain weight/altitude
    a. It presents the allowable combination of AS and LF for safe operation



E. Wingtip Vortices and Precautions to be Taken
  i. Whenever the wing is producing lift, pressure on the lower surface of the wing is greater than the upper
    a. The air tends to flow from the high-pressure area below, upward to the low-pressure area above
    b. This causes a rollup of the airflow aft of the wing and swirling air masses trailing behind the wingtips
      - The wake consists of 2 counter-rotating cylindrical vortices, one emanating from each wingtip
  ii. The strength of the vortex is governed by the weight, speed, and shape of the wing
    a. The AOA directly affects the strength
      - 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
    b. The greatest vortex strength occurs when heavy, clean, and slow (during takeoff and landing)
      - The wake of these vortices can be very dangerous and impose rolling moments exceeding the roll authority of the encountering aircraft
  iii. Vortices 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 X-wind will decrease lateral movement of the upwind and increase movement of downwind
        - a Be cautious, this could move another aircraft's vortices into your path
    - A tailwind can move the vortices of the preceding aircraft forward into the touchdown zone

iv. Avoidance
a. Wake turbulence can be a hazard to any aircraft significantly lighter than the generating aircraft
    - Could result in major structural damage, or induced rolling making the aircraft uncontrollable
b. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
    - Parallel runways – stay at and above the other jet's flight path for the possibility of drift
    - Crossing runways – cross above the larger jet's flight path
c. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path

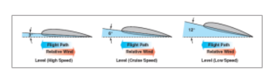
F. Forces of Flight
i. Lift – The upward force created by the effect of airflow as it passes over and under the wing
ii. Weight – Opposes lift, and is caused by the downward pull of gravity
iii. Thrust – The forward force which propels the airplane through the air
iv. Drag – Opposes thrust, and is the 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

G. 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

H. Airfoils
i. Definition
a. An airfoil is any surface, such as a wing, which provides aerodynamic force when it interacts with a moving stream of air
ii. 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

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

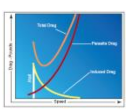


J. Weight
  i. Definition
    a. The force of gravity which acts vertically through the center of the plane toward the center of earth

        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

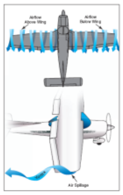
K. Thrust
    i. Thrust is the forward-acting force which opposes drag and propels the airplane
        a. This force is provided when the engine turns the prop and acts parallel to the longitudinal axis
        b. F=MA
            - Force is provided by the expansion of burning gases in the engine which 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. In order to maintain a constant AS, thrust and drag must be equal
        b. If thrust (power) is reduced the plane will decelerate as long as thrust is less than drag
            - Likewise, if AS is increased, thrust becomes greater than drag and AS increases until equal

L. 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. Two types of drag – Parasite and Induced Drag
        a. Parasite Drag
            - Caused by an aircraft surface which deflects/interferes with the smooth airflow of the airplane
            - Three Types of Parasite Drag

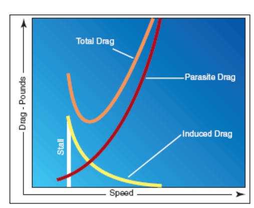


                a Form Drag: Results from the turbulent wake caused by the separation of airflow from the surface of a structure (The amount is related to the size and shape of the structure)
                    1. Basically, how aerodynamic is the aircraft?
                b Interference Drag: Occurs when varied currents or 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 in 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 AS, the greater the AOA 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
- Total drag is the sum of induced and parasite drag

M. Ground Effect
i. Associated with the reduction of induced drag
ii. Explanation
a. During takeoff/landing when you are flying very close to the ground, the earth's surface actually alters the three-dimensional airflow pattern around the airplane because the vertical component of the airflow around the wing is restricted by the ground surface
- This causes a reduction in wingtip vortices and a decrease in upwash and downwash

- Since the ground effect restricts downward deflection of the airstream, induced drag decreases

iii. Effects on Flight

a. Takeoff

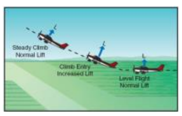
- With the reduction of induced drag, the amount of thrust required to produce lift is reduced
  - a Therefore, the airplane is capable of lifting off at lower-than-normal takeoff speed
- As you climb out of ground effect, the power (thrust) required to sustain flight increases significantly as the normal airflow around the wing returns and induced drag is increased
  - a If you climb out before reaching the normal takeoff speed you might sink back to the surface

b. Landing

- The decrease in induced drag makes the airplane seem to float
  - a Power reduction is usually required during the flare to help the airplane land

N. Climbs

i. In a steady state, normal climb the wing's lift is the same as it is in steady level flight at the same airspeed (AS)



a. Though the flight path has changed when the climb has been established, the Angle of Attack (AOA) of the wing with respect to the inclined flight path reverts to practically the same values, as does lift

ii. During the change from straight and level to a climb, a change in lift occurs when elevator is 1st applied

a. Raising the airplane's nose increases the AOA and momentarily increases lift

b. Lift at this moment is now greater than weight and starts the airplane climbing

iii. Once the flight path is stabilized, the AOA and lift revert to approximately level flight values

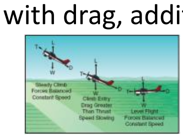
iv. If the climb is entered with no change in power settings, the AS gradually diminishes

a. This is because thrust required to maintain an AS in level flight cannot maintain the AS in a climb

b. When inclined upward, a component of weight acts in the same direction as, and parallel to drag

- This increases drag (drag is greater than thrust and therefore AS will decrease until equal)

v. 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



a. The amount of reserve power determines the climb performance

O. Descents

i. When forward pressure is applied, the AOA is decreased and, as a result, the lift of the airfoil is reduced

a. Reduction in lift/AOA is momentary and occurs during the time the flight path changes downward

b. The change to a downward flight path is due to the lift momentarily becoming less than weight

ii. When the flight path is in a steady descent, the airfoil's AOA again approaches the original value and lift and weight become stabilized

iii. From the time the descent is started until it is stabilized, the AS will gradually increase

a. This is due to a component of weight acting forward along the flight path (like rearward in a climb)

- Thrust is greater than drag

iv. To descend at the same AS, power must be reduced when the descent is entered

a. The amount of power is dependent on the steepness of the descent

- The component of weight acting forward will increase with an increase in angle of descent

P. Turns
   i. Like any moving object, an airplane requires, a sideward force to make it turn
      a. In a normal turn, this force is supplied by banking so that lift is exerted inward as well as upward
   ii. When the airplane banks, lift acts inward toward the center of the turn, as well as upward
      a. Lift is divided into two components, the horizontal component and the vertical component
         - Vertical Component – Acts vertically and opposite to weight
         - Horizontal Component – Acts horizontally toward the center of the turn (Centripetal Force)
            a This is what makes the airplane turn
      b. The division of lift reduces the amount of lift opposing gravity and supporting weight
         - Consequently, the airplane will lose altitude unless additional lift is created
            a This is done by increasing the AOA until the vertical component of lift again equals weight
         - Since the vertical component of lift decreases as bank increases, AOA must be increased as the bank angle is steepened
   iii. Holding Altitude
      a. To provide a vertical component of lift sufficient to hold altitude, an increase in the AOA is required
      b. Since drag is directly proportional to AOA, induced drag will increase as lift is increased
         - This in turn, causes a loss of AS in proportion to the angle of bank
      c. Additional power must be applied to prevent airspeed from reducing in level turns
         - The required amount of additional thrust is proportional to the angle of bank
   iv. Rate of Turn
      a. The rate at which an airplane turns depends on the magnitude of the horizontal component of lift
         - The horizontal component of lift is proportional to the angle of bank
      b. Therefore, at any given AS, the rate of turn can be controlled by adjusting the angle of bank
   v. Turning Radius
      a. Increased AS results in an increase in turn radius and centrifugal force is directly related to radius
         - The increase in the radius of the turn causes an increase in centrifugal force which must be balanced by an increase in the horizontal component of lift
            a The horizontal component of lift can only be increased by increasing bank angle
      b. To maintain a constant rate of turn with an increased AS, the angle of bank must be increased
   vi. Slipping Turns
      a. 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
         - The horizontal component (H_{CL}) of lift is greater than Centrifugal Force (CF)
      b. H_{CL} and CF equilibrium is reestablished by decreasing bank/increasing the rate of turn
         - Increase or decrease rudder pressure to center the ball or adjust bank
   vii. Skidding Turns
      a. In a skidding turn, the rate of turn is too great for the angle of bank and the plane is yawed inside the turn
         - There is excess centrifugal force compared to the H_{CL}
      b. Correction involves reducing the rate of turn/increasing the bank
         - Increase of decrease rudder pressure as necessary or adjust bank

Q. Stalls
   i. As long as the wing is creating sufficient lift to counteract the load imposed on it, the plane will fly

a. When the lift is completely lost, the airplane will stall

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

iii. The stalling speed of a particular airplane is not a fixed value for all flight situations

   a. However, a given airplane will always stall at the same AOA regardless of speed, weight, load factor, or density altitude

   b. Each plane has a particular AOA where airflow separates from the upper wing and it stalls (16^{o}-20^{o})

iv. 3 situations where the critical AOA can be exceeded:

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

   b. High Speed Flying
      - Low speed is not necessary to produce a stall
      - The wing can be brought to an excessive angle of attack at any speed
      - EX: diving at 200 knots with a sudden increase in back elevator pressure
         a Because of gravity and centrifugal force, the plane cannot immediately alter its flight path
            1. It would merely change its AOA abruptly from very low to very high
         b 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

   c. Turning Flight
      - The stalling speed of an aircraft is higher in a level turn than in straight and level flight
         a This is because the centrifugal force is added to the plane's weight
            1. The wing must produce sufficient additional lift to counteract the load imposed
      - In a turn, the necessary additional lift is acquired by applying back pressure
         a This increases the wings AOA (AOA increases with the bank angle to maintain level flight)
      - If at any time during a turn the AOA becomes excessive, the airplane will stall

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Inaccurate use of Manufacturer's Performance Charts, Tables, and Data**
   A. Ensure you understand how to properly use the performance charts
      i. Improperly used, they're worthless and dangerous - the pilot has no real grasp on the aircraft's performance abilities based on the conditions
2. **Exceeding Aircraft Limitations**
   A. Understand the limitations of the aircraft and do not exceed them
   B. It's a great idea to consistently review the aircraft limitations
      i. Not only to ensure you don't exceed them, but also so that you're aware if they are exceeded and can take the proper action
   C. Weight and Balance

        i. Always calculate any expected changes in weight and balance en route while on the ground
            a. Always find the center of gravity at takeoff and with empty tanks to ensure the center of gravity will not ever be out of limits
            b. Understand how the aircraft performance will change as the center of gravity moves
            c. An out of balance center of gravity is never something to mess around with – don't exceed limitations

3. **Possible Differences between Calculated Performance and Actual Performance**
    A. Use the performance charts and relate them to the airport information (runway lengths, climb rates vs obstacles in the area, etc.)
        i. The charts will provide performance for all phases of flight
        ii. Remember, the charts don't make an allowance for pilot proficiency or mechanical deterioration
            a. Does the airplane have problems that may limit performance?
    B. There is always the possibility of changing weather resulting in useless original calculations
        i. Just because the plane will perform well now doesn't mean it will perform well later
        ii. Plan ahead and be aware that as conditions change so does the aircraft performance. Stop and reassess the aircraft capabilities if necessary.

SKILLS

The applicant demonstrates the ability to:

1. Compute the weight and balance, correct out-of-center of gravity (CG) loading errors and determine if the weight and balance remains within limits during all phases of flight.
2. Demonstrate use of the appropriate aircraft manufacturer's approved performance charts, tables and data.

I.G. Operation of Systems

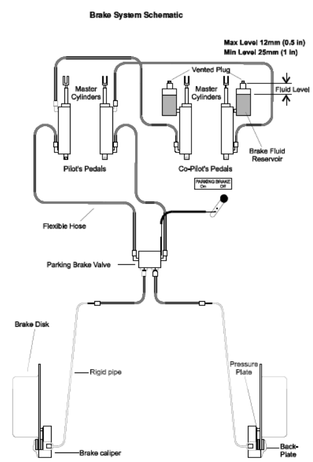
References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Major Components of Systems:**
   A. Primary Flight Controls and Trim
      i. Ailerons - Carbon Fiber Reinforced Plastic (CFRP)
         a. Actuated via push rods
         b. Attached with stainless steel and aluminum hinges
      ii. Elevator - CFRP
         a. Actuated via push rods
         b. Semi-Monocoque sandwich construction
         c. Trim
            - Controlled by a Rocker Switch
               a Switch forward = Nose Down; Switch aft = Nose Up
               b Switch controls an electrical actuator beside the vertical push rod in the vertical stabilizer
                  1. The actuator applies a load to compression springs on the elevator push rod
            - Trim circuit breaker can be tripped manually to disable the system
      iii. Rudder
         a. Actuated via control cables
         b. Semi-Monocoque sandwich construction
   B. Secondary Flight Controls: Flaps, Leading edge devices, and spoilers
      i. Driven by an electric motor
         a. Electric flap actuator is protected by a circuit breaker (5 Amp)
            - Located on the right side of the instrument panel and can be manually tripped to disable the system
      ii. Controlled by 3 position flap operating switch on the instrument panel
         a. Top position – Cruise – 0º (Green Light)
         b. Middle Position – Approach – 15º (Yellow Light)
         c. Bottom Position – Landing – 45º (Yellow Light)
         d. When two lights are illuminated at the same time, the flaps are in-between positions
      iii. Cruise and Landing positions are equipped with position switches to prevent over-traveling
   C. Powerplant and Propeller (basic engine knowledge)
      i. Powerplant
         a. Continental IO-240-B Engine
            - Fuel Injected
            - 4 Cylinder
            - 4 Stroke
            - Horizontally Opposed cylinders and heads
            - Air cooled cylinders and heads
            - Propeller drive is direct from the crankshaft
            - 3.9 liters

        - 125 HP at 2800 RPM
    - b. Engine Controls
        - Mixture Lever
        - Throttle
        - Alternate Air
            - a Full Forward = Primary Air Intake
            - b Full Aft = Alternate Air Intake
- ii. Propeller
    - a. Hoffmann HO-14HM-175-157
        - Diameter - 5’ 8.9”
        - Two-bladed fixed pitch propeller
        - Wood and glass fiber
    - b. Sensenich W69EK7-63, 63G, or W69EK-63
        - Diameter – 5’9”
        - Two-bladed fixed pitch propeller
        - Wood prop

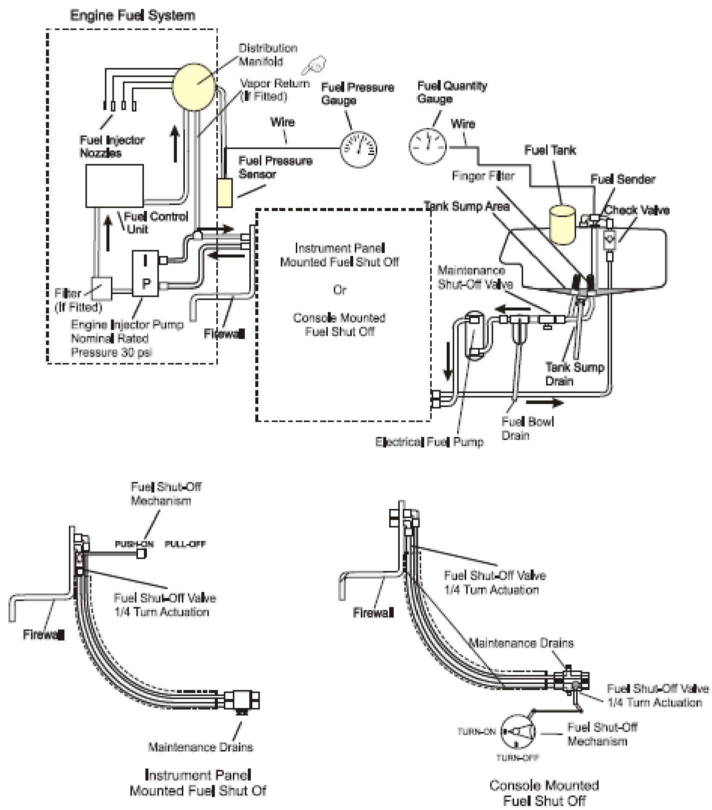


D. Landing Gear
    - a. Two main landing gear wheels (mounted to aluminum spring struts)
- ii. Nose Wheel
    - a. 60^{o} castering
    - b. Suspension is provided by an elastomer spring
- iii. Wheel Brakes
    - a. Hydraulically operated disc brakes
    - b. Operated individually using toe-brake pedals
- iv. Parking Brake
    - a. Repeated pushing of the toe-brake pedals will build up the required brake pressure, which will remain in effect until the brake is released

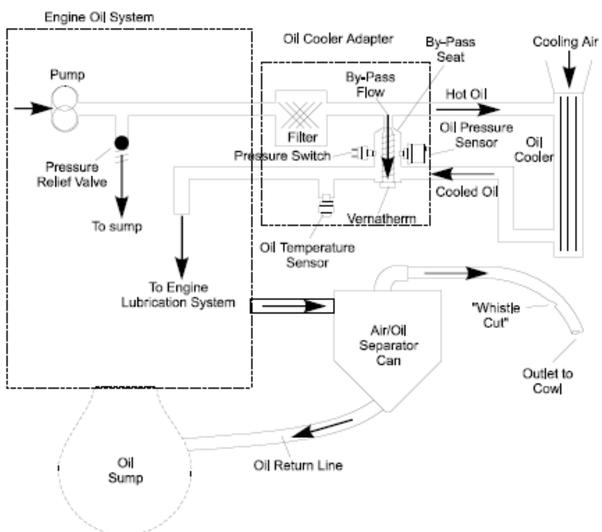
E. Fuel, Oil, and Hydraulic
- i. Fuel
    - a. Aluminum Fuel Tank
        - Located behind the seats, below the baggage compartment
        - 24.5 Gallons fuel (24 Gallons Usable)
        - Operation
            - a Fuel is gravity fed to a filter bowl (gascolator) and then to the electric fuel pump
                - 1. Filter bowl must be drained before flight (black tube)
            - b Electric fuel pump primes for starting (Prime ON) and is used for low throttle operations
                - 1. When the pump is off, fuel flows through the pump’s internal bypass
            - c From electric pump, fuel is delivered to the mechanical fuel pump by the fuel supply line
            - d Fuel is metered by the fuel control unit and flows via the fuel distribution manifold to the injector nozzles
            - e Return line from mechanical fuel pump’s fuel vapor separator returns vapor/excess fuel to the tank
        - Electric Fuel Pump
            - a DUKES constant flow, vane type, two speed, electric fuel pump
                - 1. Fuel Prime
                    - a. Pump’s high-speed setting, used for priming the engine prior to engine start

b. Turning the prime pump on while running will enrich the mixture considerably
   i. At high throttle settings the effect is less noticeable
   ii. At low throttle settings may cause engine roughness or engine stoppage
2. Fuel pump
   a. Required for maintaining positive fuel pressures at low throttle settings

- Fuel Shutoff Valve
  a Closing will cause the engine to stop within a few seconds



ii. Oil
   a. High pressure wet sump lubrication system
      - Wet sump oil systems store the oil in the engine pan, dry sump systems store the oil in a separate tank
   b. Oil is pumped by a mechanical, engine driven pump
   c. Oil must be between 4 and 6 quarts



iii. Hydraulic
  a. None in the DA20

F. Electrical
  i. Power Generation
    a. 40 Amp Generator
      - Feeds the Main Bus via the Generator Circuit Breaker (50 Amps)
    b. Generator Warning Light
      - Activated by internal voltage regulator monitoring circuit - illuminates if generator fault occurs
  ii. Power Storage
    a. 12V battery
      - Connects to the Master Bus via the Battery Circuit Breaker (50 Amps)
  iii. Power Distribution
    a. Electrical Bus
  iv. Consumers
    a. Individual consumers (e.g., Radio, Fuel Pump, Position Lights, etc.) are connected in series with their respective circuit breakers
  v. Electrical Monitoring Instruments
    a. Voltmeter
      - Indicates the status of the Electrical Bus
      - Consists of a dial marked numerically from 8 – 16 volts in divisions of 2
        a Scale
          1. RED for 8.0 - 11.0 volts
          2. YELLOW for 11.0 - 12.5 volts
          3. Green for 12.5 - 16.0 volts
          4. REDLINE at 16.1 volts
    b. Ammeter
      - Indicates the charging (+) and discharging (-) of the battery
      - Consists of a dial which is marked numerically from -60 to 60 amps
    c. Generator Warning Light
      - Illuminates during generator failure
        a No output from the generator

- The only remaining power source is the battery (20 Amps for 30 min)

G. Avionics
    i. Center of the instrument panel contains the radio and navigation equipment
        a. Operating instructions should be taken from the manuals of the respective manufacturers
    ii. Vertical Stabilizer contains the antenna for the VHF radio equipment
    iii. Horizontal Stabilizer contains the antenna for the NAV equipment (VOR)

H. Pitot-Static, Vacuum/Pressure and Associated Flight Instruments
    i. Pitot-Static
        a. Pitot pressure is measured on the leading edge of a calibrated probe below the left wing
            - Airspeed indicating error, refer to Chapter 5 of POH
        b. Static pressure is measured by the same probe
            - Error of the static pressure system is negligible
        c. Instruments
            - Airspeed Indicator
                a Pitot Pressure (Ram Air Pressure) and Static Pressure
            - Altimeter
                a Static Pressure
            - Rate of Climb Indicator
                a Static Pressure
    ii. Vacuum Pressure (Gyros)
        a. Instruments
            - Heading Indicator
            - Attitude Indicator
    iii. Electrically Driven Instruments
        a. Turn Coordinator

I. Environmental
    i. Cabin Heat and Defrost
        a. Directs ram air through the exhaust heat shroud into the cabin heat valve
            - The air is directed to the window defrosting vents and to the cabin floor as selected by the lever
        b. The cabin heat selector is used to regulate the flow of heated air

J. Deicing and Anti-Icing
    i. Defrost
        a. Can be used to deice the windshield (if the icing is light)

K. Oxygen System

This is a little more in depth than intended, especially since most aircraft don't have an oxygen system, but the ACS moved the oxygen information from another lesson. Rather than limiting the amount of information, it's all here if needed.

    i. Regulatory Requirements
        a. No person may operate a civil aircraft of US registry at cabin pressure altitudes above:
            - 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
            - 14,000' unless the required min flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes
            - 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:

- FL 250 unless at least a 10-minute supply of supplemental oxygen is available for each occupant of the aircraft for use in the event that a descent is necessitated by a loss of cabin pressure
    - a This is in addition to oxygen required above
- FL 350, unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed
    - a The mask must supply oxygen at all times or automatically supply oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000’ MSL
    - b 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
    - c If one pilot leaves the controls, the remaining pilot shall put on and use and oxygen mask until the other pilot has returned

ii. System Operational Guidelines

a. Refer to the guidelines associated with the specific system to be used

b. General Overview

- Types of Oxygen Systems
    - a Continuous Flow
        1. Most common in GA planes
        2. Usually for passengers and has a reservoir bag which collects oxygen from the system when exhaling
        3. Ambient air is added to the oxygen during inhalation after the reservoir oxygen supply is depleted
        4. Exhaled air is released into the cabin
    - b Diluter Demand – Supply oxygen only when the user inhales through the mask
        1. Depending on the altitude, the regulator can provide 100% oxygen or mix cabin air and the oxygen
        2. The mask provides a tight seal and can be used safely up to 40,000’
    - c Pressure Demand – oxygen is supplied to the mask under pressure at cabin altitudes above 34,000’
        1. Provide a positive pressure application of oxygen that allow the lungs to be pressurized with oxygen
        2. Safe at altitudes above 40,000’
        3. Some systems include the regulator on the mask to eliminate purging a long hose of air
- Aviator’s Breathing Oxygen
    - a Aviators’ oxygen is specified at 99.5% pure oxygen and not more than .005mg of water per liter
        1. It is recommended that aviator’s breathing oxygen be used at all times, medical and industrial oxygen may not be safe
    - b Medical oxygen has too much water, which can collect in various parts of the system and freeze
        1. Freezing may reduce/stop the flow of oxygen
    - c Industrial oxygen is not intended for breathing and may have impurities in it (metal shavings, etc.)

iii. System Checks

a. Refer to the guidelines associated with the specific system to be used

b. General Guidelines
- Care and Storage of High-Pressure Oxygen Bottles
    - a If the airplane does not have a fixed installation bottle, portable oxygen equipment must be accessible in flight
    - b Oxygen is usually stored at 1,800 – 2,200 psi
        1. When the ambient temperature surrounding the cylinder decreases, pressure within will decrease
            a. If a drop in indicated pressure is noted due to temperature, there is no reason to suspect depletion of the supply
        2. High pressure containers should be marked with the psi tolerance before filling to the pressure
    - c Be aware of the danger of fire when using oxygen
        1. Materials that are nearly fire proof in ordinary air may be susceptible to burning in pure oxygen
            a. Oils and greases may catch fire if exposed to pure oxygen and cannot be in oxygen systems
        2. Smoking during any kind of oxygen equipment use is prohibited
        3. Before each flight, thoroughly inspect and test all oxygen equipment
    - d Examine the equipment - available supply, operational check, and assure it is readily available
    - e To assure safety, periodic inspections and servicing should be done

2. Indications of and Procedures for Managing System Abnormalities or Failures

A. Normal Operation of Systems
- i. Normal operation includes a myriad of factors, but in general:
    - a. Gauges in their normal (green) ranges
    - b. You should not experience: Abnormal noises, rough running/coughing engine, abnormal smells (especially electrical fire – very distinct smell), difficult or rough moving flight controls/engine control levers (throttle, mixture, etc.), flickering lights/dials, etc.
    - c. As a general rule, if it doesn't seem right, it probably isn't

B. Common Errors made by Pilots
- i. Ignoring an abnormal indication
    - a. If something doesn't feel right, it probably isn't – take action to figure out and fix the problem rather than waiting for it to become a serious failure or emergency
    - b. Misdiagnosing a failure or malfunction
        - Aircraft get considerably more complex as you move up from single engine pistons. It becomes considerably easier to confuse or misdiagnose a problem
        - The Air Force teaches a very specific way of handling a problem in order to help properly diagnose the situation and take the proper action
            - a 1. Maintain aircraft control
                - a. Put the aircraft in a safe flight position – probably straight and level flight, although you may want to continue a climb or descent depending on the situation
            - b 2. Analyze the Situation
                - a. With the aircraft in a safe position, analyze everything inside and outside the aircraft
                    - i. Analyze any warning lights, gauges, engine instruments, sounds, the aircraft's appearance, everything you can in order to obtain a full picture of the situation and properly diagnose the situation

b. Once the situation has been analyzed, state the problem

c 3. Take the Proper Action

a. Refer to any checklists or emergency procedures that are associated with the problem (use the POH)

b. Talk to anyone who can help (ATC, Guard, etc.)

d 4. Land as Soon as conditions Permit

a. Get the airplane on the ground in order to terminate any potential emergency

c. Panicking

- Don't panic!
- That's one reason the Air Force uses the process described above, it provides a simple step by step procedure in order to safely diagnose a problem, attempt to fix it, and get the aircraft on the ground

a Maintain aircraft control. Analyze the Situation. Take the Proper Action. Land as soon as conditions Permit.

C. Abnormal Operation of Systems (recognizing failures/malfunctions)

i. A warning light is often the first indication of a failure or malfunction. Obviously, abnormal system operation can warn of an impending failure or malfunction.

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Failure to detect System Malfunctions or Failures**

A. If it doesn't feel right, it probably isn't right

i. Be familiar with the aircraft. When not flying, the POH can provide the best info as to what is normal

B. If something appears out of the ordinary, attempt to troubleshoot the problem while maneuvering to an alternate or emergency airfield

C. Safety First

2. **Improper Management of a System Failure**

A. Use the steps described above

i. Analyze the Situation

a. Take everything into account in order to diagnose the situation

- Just because an engine is running rough doesn't mean the engine itself has a problem. It could be the fuel supply or a clogged air supply, or an incorrect setting inside the cockpit.

B. Always follow a checklist

i. The POH describes the correct operation of the systems, incorrect operation can lead to decreased performance, failures, etc.

a. Manage the systems as directed by the POH

C. If you misdiagnosed the problem, undo what you did and continue with the new checklist

D. Don't Panic!

3. **Failure to Monitor and Manage Automated Systems**

A. Ineffective monitoring of automation can lead to a lot of trouble

B. Many autopilots can fly the aircraft directly into the ground if not programmed correctly and if the errors are not caught. Always double check that the automation is doing what you want it to do. If it is not, fix it or turn it off and fly the plane.

i. Do not continue to fly with automation that isn't working as desired.

SKILLS

The applicant demonstrates the ability to:

1. Explain and operate at least three of the systems listed in K1a through K1l above.
2. Use appropriate checklists properly.

I.H Human Factors

References: Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Risk Management Handbook (FAA-H-8083-2), AIM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Aeromedical and Physiological Issues**
    A. Hypoxia
        i. Hypoxia means "reduced oxygen" or "not enough oxygen"
            a. The most concern is with getting enough oxygen to the brain, since it is particularly vulnerable to oxygen deprivation
            b. Hypoxia can be caused by several factors including:
                - An insufficient supply of oxygen
                - Inadequate transportation of oxygen
                - Inability of the body tissues to use oxygen
        ii. Hypoxic Hypoxia
            a. A result of insufficient oxygen available to the lungs
            b. A blocked airway or drowning are examples of how the lungs can be deprived of oxygen
            c. For Pilots: The reduction in partial pressure of oxygen at high altitude is a common example
                - Partial Pressure is the amount of pressure that a single gas (out of a mixture) contributes to the total pressure
            d. Although the percentage of oxygen in the atmosphere is constant with changes in altitude, the partial pressure decreases as altitude increases
                - 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
                - The decrease of oxygen molecules at sufficient pressure leads to hypoxic hypoxia
        iii. Hypemic Hypoxia
            a. Occurs when the blood is not able to take up and transport sufficient oxygen to the cells in the body
            b. Hypemic means "not enough blood"
            c. This type of hypoxia is a result of oxygen deficiency in the blood
            d. Possible Causes:
                - Not enough blood volume
                    a Can be caused by severe bleed or blood donation
                - Certain blood diseases, such as anemia
                - Hemoglobin, the molecule that transports oxygen, is unable to bind oxygen molecules
                - Carbon monoxide poisoning
        iv. Stagnant Hypoxia
            a. Stagnant means "not flowing;" stagnant hypoxia results when the oxygen rich blood in the lungs isn't moving to the tissues that need it
                - Ex. An arm or leg going to sleep because the blood flow has been restricted
            b. This type of hypoxia can result from:
                - Shock
                - The heart failing to pump blood effectively
                - A constricted artery

c. During flight, stagnant hypoxia can occur when pulling excessive positive G's
d. Cold temperatures can also decrease the blood supplied to extremities

v. Histotoxic Hypoxia
a. The inability of the cells to effectively use oxygen
- "Histo" refers to tissues or cells, and "Toxic" means poison

b. In this case, oxygen is being transported to the cells, but they are unable to use it
c. Causes:
- Alcohol and other drugs, such as narcotics and poison
  - a Drinking an ounce of alcohol is equivalent to an additional 2,000' of altitude

vi. Symptoms of Hypoxia
a. The first symptoms are euphoria and a carefree feeling. With increased oxygen starvation, the extremities become less responsive and flying becomes less coordinated.
b. As it worsens, vision narrows, concentration and instrument interpretation become difficult
c. Common symptoms include:
- Cyanosis (blue fingernails and lips)
- Headache
- Decreased reaction time
- Impaired judgment
- Euphoria
- Visual Impairment
- Drowsiness
- Lightheaded or dizzy sensation
- Tingling in fingers or toes
- Numbness
- 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)

vii. Useful Consciousness
a. Describes the maximum time the pilot has to make rational, lifesaving decisions and carry them out at a given altitude without supplemental oxygen
b. As altitude increases above 10,000 ft., the symptoms of hypoxia increase in severity, and the 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

viii. Treatment
a. Flying at lower altitudes
- Emergency Descent

b. Use supplemental oxygen immediately

B. Hyperventilation

i. Occurs when an individual is experiencing emotional stress, fright, or pain, and the breathing rate and depth increase
    a. The 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
ii. Pilots encountering a stressful situation may unconsciously increase their breathing rate
    a. If flying at higher altitudes, with or without oxygen, a pilot may have a tendency to breathe more rapidly than normal, which can lead to hyperventilation
iii. Since many symptoms of hyperventilation are similar to those of hypoxia, it is important to correctly diagnose and treat the proper condition.
iv. Common Symptoms:
    a. Headache
    b. Decreased reaction time
    c. Impaired judgment
    d. Euphoria
    e. Visual Impairment
    f. Drowsiness
    g. Lightheaded or dizzy sensation
    h. Tingling in fingers and toes
    i. Numbness
    j. Pale, clammy appearance
    k. Muscle spasms
v. Treatment
    a. Involves restoring the proper carbon dioxide level in the body
    b. If using supplemental oxygen, check the equipment and flow rate to ensure the symptoms are not hypoxia related
    c. Breathing normally is both the best prevention and the best cure for hyperventilation
    d. Breathing into a paper bag or talking aloud helps to overcome hyperventilation
    e. Recovery is usually rapid once the breathing rate is returned to normal
    f. Because hyperventilation and hypoxia symptoms are so similar, if unsure, it is best to treat the hypoxia as it the more threatening situation

C. Middle Ear and Sinus Problems
  i. Middle Ear Problems
    a. Explanation
      - There is a difference between the pressure of the air outside the body and the air inside the middle ear and nasal sinuses
      - The middle ear is a small cavity located in the bone of the skull
        a Normally, the pressure difference between the middle ear and the outside world are equalized by the Eustachian Tube
          1. A tube leading from inside each ear to the back of the throat on each side
          2. These tubes are usually closed, but open during chewing, yawning or swallowing to equalize pressure
    b. Symptoms
      - Pain is the primary indicator
        a The pain can be excessive and damage can be done to the eardrums if the pressure differential is too great
      - Temporary reduction in hearing sensitivity
    c. Relation to flying

- During a climb, if the air pressure in the Eustachian tube cannot equalize (remains at ground level), while the pressure on the outside of the eardrum decreases the eardrum will bulge outward resulting in discomfort
- During a descent, the reverse happens: as the aircraft descends, the pressure on the outside of the eardrum increases while the pressure in the Eustachian tube remains at altitude, resulting in the eardrum bulging inward causing discomfort
- Excessive pressure in either situation can result in pain and a ruptured ear drum

d. Treatment
- If minor, chew gum or stretch the jaw to attempt to equalize pressure
- Pinch the nostrils, close the mouth, and blow slowly and gently in the mouth and nose
  - a This forces air into the Eustachian tube allowing the pressure to equalize
  - b It may not be possible to equalize the pressure in the ears if a pilot has a cold, an ear infection, or sore throat
  - c This treatment is more helpful in a descent
    1. Be cautious in a climb, forcing air into the Eustachian tube may add more pressure and force the eardrum farther outward leading to increased pain
- If experiencing minor congestion, nose drops or nasal sprays may reduce painful ear blockage

ii. Sinus Problems

a. Explanation
- Air pressure in the sinuses equalizes with the pressure in the cockpit through small openings that connect the sinuses to the nasal passages
- An upper respiratory infection (cold or sinusitis) or a nasal allergic condition can produce enough congestion around an opening to slow equalization

b. Symptoms
- Pain over the sinus area (pain can become excessive)
- Some sinus blocks can make the upper teeth ache
- Bloody mucus may discharge from the nasal passages

c. Relation to flying
- As the difference in pressure between the sinus and the cockpit increases, congestion may plug the sinus' openings
- The "sinus block" occurs most frequently during descents

d. Treatment
- Slow descent rates can reduce the associated pain
- Do not fly with sinus problems (avoid the situation entirely)

D. Spatial Disorientation

i. Explanation

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

b. Disorientation is the lack of orientation

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

d. The body uses three systems to ascertain orientation and movement in space
- Visual: The eye, by far the largest source of information
- Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons

- Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space

e. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving

ii. Relation to flight

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

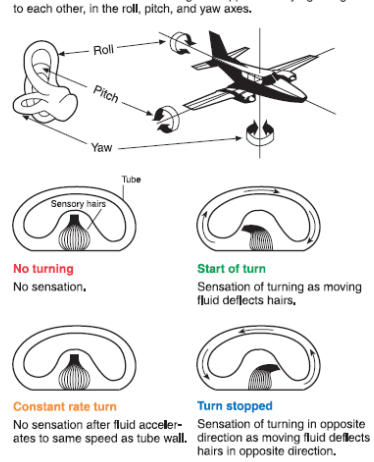
b. Visual System (eyes)
- Flight in VMC
  - a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
- Flight in IMC
  - a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented

c. Vestibular System (ears)
- The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
- Two major parts: Semicircular Canals and Otolith Organs
- Semicircular Canals
- Explanation
  1. Detect angular acceleration
  2. Three tubes at right angles to each other
     a. One on each of the three axes; pitch, roll, and yaw
  3. Each canal is filled with a fluid, called Endolymph Fluid
  4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves

b How they work: In a Turn

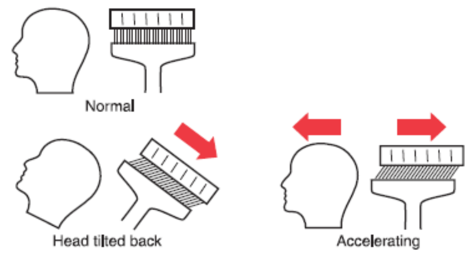
1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
   a. Glass of water illustration: wall is moving but water is not
2. The ear only detects turns of a short duration
   a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
   b. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)
      i. Glass of water illustration: water matches the speed of the glass
   c. When the turning stops, the ear canal stops moving but the fluid does not
      i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight
3. This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after

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



about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.

- Otolith Organs
  - a Explanation
    1. Detect linear acceleration/gravity
    2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
    3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift



  - b Acceleration
    1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

d. Postural System (nerves)
- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- Acceleration will be felt as the pilot is pushed back into the seat
- False Sensations
  - a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
    1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
  - b Turbulence can create motions that confuse the brain
  - c Fatigue or illness can exacerbate these sensations

iii. Countering the sensations
  - a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments

b. The pilot must have an understanding of the problem and the self-confidence to control the aircraft using only instrument indications (do not trust the feelings, trust the instruments)

E. Motion Sickness
- i. Cause
  - a. Caused by the brain receiving conflicting messages about the state of the body
  - b. Anxiety and stress also affect motion sickness
- ii. Symptoms
  - a. General discomfort
  - b. Nausea
  - c. Dizziness
  - d. Paleness
  - e. Sweating
  - f. Vomiting
- iii. Treatment
  - a. Open fresh air vents
  - b. Focus on objects outside the airplane
  - c. Avoid unnecessary head movement

d. Take control of the aircraft and fly smooth, straight and level
    - Letting someone else fly can make the situation worse

e. Generally, goes away after a few flight lessons
    - After more used to flying and stress/anxiety are reduced

F. Carbon Monoxide Poisoning

i. How it Happens – In the Plane

a. Carbon Monoxide (CO) is a colorless, odorless gas produced by all internal combustion engines

b. Aircraft heater vents and defrost vents provide CO a passageway into the cabin if the engine exhaust system has a leak or is damaged

ii. How it Happens – In the Body

a. CO attaches itself to the hemoglobin in the blood
    - It does this about 200 times easier than oxygen
    - CO prevents the hemoglobin from carrying oxygen to the cells resulting in Hypemic Hypoxia

b. It can take up to 48 hours for the body to dispose of CO

c. If the poison is severe enough it can result in death

iii. Effects of CO

a. Headache

b. Blurred vision

c. Dizziness

d. Drowsiness

e. Loss of muscle power

iv. Detecting and Correction

a. If a strong odor of exhaust gases is detected, assume CO is present
    - CO may be present in dangerous amounts even if no exhaust odor is detected

b. If exhaust odor is noticed or symptoms are experienced immediate actions should be taken
    - Turn off the heater
    - Open fresh air vents and windows
    - Use supplemental oxygen, if available
    - Land

G. Stress and Fatigue

i. Fatigue

a. Effects
    - Degradation of attention and concentration
    - Impaired coordination
    - Decreased ability to communicate

b. Causes
    - Sleep loss
    - Exercise
    - Physical work
    - Stress and prolonged performance of cognitive work can result in mental fatigue

c. Categories
    - Acute Fatigue (short term)
        a Definition
            1. Tiredness felt after a period of strenuous effort, excitement, or lack of sleep
            2. Normal occurrence in everyday life
        b Skill Fatigue – A special type of acute fatigue affecting a person's piloting skill
            1. Effects on performance

a. Timing Disruption
   i. Appearing to perform a task as usual, but the timing of each component is slightly off
   ii. Performance 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
   i. Concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery
   ii. May be accompanied by a loss of accuracy/smoothness in control movements

c Causes
1. Mild hypoxia
2. Physical stress
3. Psychological stress
4. Depletion of physical energy resulting from psychological stress

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

- Chronic Fatigue

a Definition
1. Fatigue extending over a long period of time
2. Usually has psychological roots, an underlying disease is sometimes responsible

b Symptoms
1. Weakness
2. Tiredness
3. Palpitations of the heart
4. Breathlessness
5. Headaches
6. Irritability
7. Stomach or intestinal problems (Rarer)
8. Generalized aches and pains throughout the body
9. Emotional Illness (when conditions become serious enough)

c Prevention
1. Usually requires treatment by a physician

d. Prevention
- If suffering from acute fatigue, stay on the ground
- Fatigue in the cockpit cannot be overcome through training or experience
- Getting adequate rest is the only way to prevent fatigue

a Avoid flying without:
1. A full night's rest
2. After working excessive hours
3. After an especially exhausting or stressful day

- Suspected chronic fatigue should be treated by a physician

ii. Stress

a. The body's response to physical and psychological demands placed upon it
b. Body's Reaction
    - Releasing chemical hormones (such as adrenaline) into the blood
    - Increasing metabolism to provide more energy to the muscles
    - Blood sugar, heart rate, respiration, blood pressure, and perspiration all increase
c. Stressors
    - Physical stress (noise or vibration)
    - Physiological stress (fatigue)
    - Psychological stress (difficult work or personal situations)
d. Categories of Stress
    - Acute Stress (short term)
        a Involves an immediate threat that is perceived as danger
        b The type of stress that triggers a "fight or flight" response in an individual
        c Normally, a healthy person can cope with acute stress and prevent stress overload
        d On-going acute stress can develop into chronic stress
e. Chronic Stress (long term)
    - A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
    - Causes
        a Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
    - Pilots experiencing this level of stress are not safe and should not fly

H. Dehydration and Nutrition
  i. Dehydration
    a. Critical loss of water from the body
    b. Effects
        - First noticeable effect is fatigue
            a Top physical and mental performance is difficult, if not impossible
    c. How it affects flying
        - Flying for long periods of time in hot temperatures or at high altitudes increases the susceptibility of dehydration since the dry air at altitude increases the rate of water loss from the body
        - If the fluid is not replaced, fatigue progresses to dizziness, weakness, nausea, tingling of the hands and feet, abdominal cramps, and extreme thirst
        - Attention is taken from flying and skills diminish
    d. Prevention
        - Carry an ample supply of water on any flight
        - If the airplane has a canopy or roof window, wearing light colored, porous clothing and a hat will provide protection
        - Keep the cockpit well ventilated
  ii. Nutrition
    a. A lack of nourishment can impact a pilot's ability to safely fly an aircraft
    b. The effects are very similar to dehydration
        - Fatigue
        - Irritability
        - Diminished mental and physical performance
        - Distraction

c. Prevention
   - Eat prior and, if necessary, in flight to ensure proper nourishment

I. Hypothermia
   i. A situation where the core body temperature drops below the normal range
   ii. As the temperature drops the person experiences different effects
      a. Shivering (most common)
      b. Increased breathing rate
      c. Cold extremities (hands, and feet), followed by blue fingers, toes, and lips
      d. Motor skills become slower
      e. Diminished mental judgement and decision making
      f. In extreme cases, death can result
   iii. Hypothermia and Flying
      a. Flying in cold temperatures (or at high altitudes where the air is cold) can lead to hypothermia if the pilot is not prepared
         - Use cabin heat (if broken consider not going)
         - Dress properly (wear warm clothes)
         - If you can't keep the cabin warm, land. Do not risk continuing

J. Optical Illusions
   i. Many illusions can lead to a dangerous situation if the pilot is not aware they exist and how to recognize and avoid them
   ii. Preventing landing Illusions
      a. Anticipate them during approaches
      b. Aerial visual inspection of unfamiliar airports
      c. Using glide slope or VASI/PAPI systems whenever possible
      d. Maintaining optimum proficiency in landing procedures
   iii. Runway Width Illusion
      a. Reason
         - A narrower than usual runway
         - A wider than usual runway
      b. Illusion
         - Narrow - Can create the illusion that the aircraft is at a higher altitude than it actually is
         - Wide - Can create the illusion that the aircraft is at a lower altitude than it actually is
      c. Result
         - 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
         - 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
   iv. Runway and Terrain Slope Illusion
      a. Reason
         - An up-sloping runway, up sloping terrain, or both
         - A down sloping runway, down sloping terrain, or both
      b. Illusion
         - Upslope – Can create the illusion that the aircraft is at a higher altitude than it actually is
         - Downslope – Can create the illusion that the aircraft is at a lower altitude than it actually is
      c. Result
         - Upslope – The pilot who does not recognize this will fly a lower approach
         - Downslope – The pilot who does not recognize this will fly a higher approach

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

vi. Atmospheric Illusions
    a. Reason
        - Rain on the windscreen
        - Atmospheric Haze
        - Penetration of fog
    b. Illusion
        - Rain - Can create the illusion of greater height
        - Atmospheric Haze – Can create the illusion of distance
        - Penetration of Fog – Can create the illusion of pitching up
    c. Result
        - Rain & Haze - The pilot who does not recognize these illusions will fly a lower approach
        - Fog – The pilot who does not recognize this will steepen the approach (descent), often quite abruptly

vii. Ground Lighting Illusions
    a. Reason
        - Lights along a straight path, such as a road, and even lights on moving trains
    b. Illusions
        - Can create the illusion of runway and approach lighting systems
    c. Result
        - The pilot may attempt to land on a path, road, or train
    d. Reason
        - Bright runway and approach light systems
    e. Illusion
        - Can create the illusion of less distance to the runway
            a Especially where few lights illuminate the surrounding terrain
    f. Result
        - The pilot who does not recognize this illusion will fly a higher approach

K. Dissolved Nitrogen in the Bloodstream After Scuba Dives
    i. Provide the body with enough time to rid itself of excess nitrogen absorbed from diving
        a. Decompression sickness can occur and create an in-flight emergency
            - Nitrogen bubbles can form in the bloodstream, spinal cord or brain as pressure decreases with altitude
                a In extreme cases this can result in death, in less severe cases this can result in impairment or severe pain
            - Wait at least 12 hours after a dive not requiring a controlled ascent before flight up to 8,000'
                a For flights above 8,000' wait at least 24 hrs.
            - Wait at least 24 hours after a dive which required a controlled ascent
        b. If a decompression is experienced (especially a rapid decompression) symptoms can be brought on quickly

2. Regulations Regarding the Use of Alcohol and Drugs

A. FAR 91.17: No person may act, or attempt to act as a crewmember of a civil aircraft:
   i. Within 8 hours after the consumption of any alcoholic beverage
   ii. While under the influence of alcohol
   iii. While using any drug that affects the person's faculties in any way contrary to safety; or
   iv. While having an alcohol concentration of 0.04 or greater in a blood or breath specimen.

B. FAR 91.17(b): Except in an emergency, no pilot of a civil aircraft may allow a person who appears to be intoxicated or who demonstrates by manner or physical indications that the individual is under the influence of drugs (except a medical patient under proper care) to be carried in that aircraft.

C. FAR 91.19:
   i. Except as provided in paragraph (b) of this section, no person may operate a civil aircraft within the United States with knowledge that narcotic drugs, marihuana, and depressant or stimulant drugs or substances as defined in Federal or State statutes are carried in the aircraft.

D. DON'T drink and fly
   i. A hangover can impair anyone attempting to fly
   ii. More susceptible to disorientation and hypoxia
   iii. FARS – 8 hours 'from bottle to throttle' (8 hrs. + not feeling the effects of alcohol is better)

E. Medications and drugs
   i. Can affect pilot performance
      a. Side effects include impaired judgment, coordination, vision
   ii. Anything that depresses nervous system can make a pilot more susceptible to hypoxia
   iii. Do not fly while taking any medication, unless approved by the FAA

3. 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
   i. It is estimated that approximately 80% of all aviation accidents are a result of human factors
      a. Good ADM is important

B. Teaching pilots to make sound decisions is the key to preventing accidents

C. The Decision-Making Process
   i. Defining the Problem
      a. Recognize that a change has occurred and the expected result did not occur
      b. Incorrectly defining the problem can create a worse problem
   ii. Choosing a Course of Action
      a. Evaluate the need to react and determine what available actions can solve the problem in the time available
   iii. Implementing the Decision and Evaluating the Outcome
      a. Continue to evaluate how the decision will affect the flight
   iv. Very similar to Maintain aircraft control, analyze the situation, take the proper action, land as soon as conditions permit as discussed in I.G. Operation of Systems, above

D. Factors Affecting Decision Making
   i. Recognizing Hazardous Attitudes
      a. Must be able to spot hazardous attitudes and remove them

The Five Hazardous Attitudes
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 pilot prerogative to question authority if it seems to be in error.
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.
Invulnerability: "It won't happen to me." Many people believe that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. 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.
Macho: "I can do it." Pilots who are always trying to prove that they are better than anyone else are thinking, "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.
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 me," 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."

Hazardous Attitude	Antidotes
Macho Steve often brags to his friends about his skills as a pilot and how close to the ground he flies. During a local pleasure flight in his single-engine airplane, he decides to buzz some friends barbecuing at a nearby park.	**Taking chances is foolish.**
Anti-authority Although he knows that flying so low to the ground is prohibited by the regulations, he feels that the regulations are too restrictive in some circumstances.	**Follow the rules. They are usually right.**
Invulnerability Steve is not worried about an accident since he has flown this low many times before and he has not had any problems.	**It could happen to me.**
Impulsivity As he is buzzing the park, the airplane does not climb as well as Steve had anticipated and, without thinking, he pulls back hard on the yoke. The airspeed drops and the airplane is close to stalling as the wing brushes a power line.	**Not so fast. Think first.**
Resignation Although Steve manages to recover, the wing sustains minor damage. Steve thinks to himself, "It doesn't really matter how much effort I put in—the end result is the same whether I really try or not."	**I'm not helpless. I can make a difference.**

Stressors
Physical Stress Conditions associated with the environment, such as temperature and humidity extremes, noise, vibration, and lack of oxygen.
Physiological Stress Physical conditions, such as fatigue, lack of physical fitness, sleep loss, missed meals (leading to low blood sugar levels), and illness.
Psychological Stress Social or emotional factors, such as a death in the family, a divorce, a sick child, or a demotion at work. This type of stress may also be related to mental workload, such as analyzing a problem, navigating an aircraft, or making decisions.

ii. Stress Management
   a. A certain amount of stress is normal/good
   b. Too much can be very bad
   c. 3 types of stress that affect performance
      - Physical
      - Physiological
      - Psychological

E. Use of Resources
   i. Use all available resources, think outside the box
   ii. Internal Resources
      a. Found in the flight deck during flight
         - Equipment, systems, charts, books, etc.
         - Also, ingenuity, knowledge and skill
         - Other passengers
   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
   v. 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, manage tasks in order of importance when behind

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Aeromedical and Physiological Issues

A. Be aware
   i. A pilot who is knowledgeable and familiar with the potential issues experienced in flight is much better prepared to handle the situation before it becomes a danger
      a. Follow the rules (alcohol, drugs, etc.) and understand what affects your ability to fly
      b. Understand how the body interprets motion to counter illusions and spatial disorientation
         - Don't fall for the illusions/spatial disorientation

B. Medication's Physiological Effects
   i. The FARs include no specific references to medication usage. Two regulations, although, are important:
      a. FAR 61.53: Prohibits acting as PIC or in any other capacity as a required crewmember, while that person:
         - Knows or has reason to know of any medical condition that would make the person unable to meet the requirement for the medical certificate necessary for the pilot operation, or

        - Is taking medication or receiving other treatment for a medical condition that results in the person being unable to meet the requirements for the medical certificate necessary for the pilot operation
      b. FAR 91.17: Prohibits the use of any drug that affects the person's faculties in any way contrary to safety.
   ii. Drugs that have no apparent side effects on the ground can create serious problems at even relatively low altitudes
      a. Even at typical general aviation altitudes, the changes in concentrations of atmospheric gases in the blood can enhance the effects of seemingly innocuous drugs
         - This can result in impaired judgement, decision-making, and performance
      b. In addition, fatigue, stress, dehydration, and inadequate nutrition can increase susceptibility to adverse effects from various drugs
      c. If multiple drugs are being taken at the same time, the adverse effects can be more pronounced
   iii. Some of the most common over-the-counter drugs have the potential to cause noticeable side effects, including drowsiness and cognitive deficits.
      a. Particularly, drugs with diphenhydramine (like Benadryl) are known to cause drowsiness and stay in one's system for an extended time
   iv. Pain Killers
      a. Drugs that reduce pain (Aspirin, Tylenol, Advil) have few side effects when taken in the correct dosage
         - Flying is usually not restricted with these drugs
      b. Drugs that deaden pain or cause loss of consciousness (Darvon, Percodan, Demerol, Codeine) are known to cause side effects such as confusion, dizziness, headaches, nausea, and vision problems
         - Flying is almost always unacceptable with these drugs
   v. Stimulants and Depressants
      a. Stimulants can produce anxiety and mood swings, both dangerous when flying
      b. Depressants (like alcohol and some stomach medications or decongestants) can lower blood pressure, reduce mental processing and slow motor and reaction responses
C. Do not fly as a crewmember while using any medication, unless approved by the FAA
   i. If there is any doubt, ask an AME
   ii. Additionally, you should wait at least 5 maximal dosing intervals (the time between recommended dosing – i.e., a dosing interval of 5-6 hours would require you to wait 30 hours) before flying after taking any medication that has potentially adverse side effects
      a. This is generally a reasonable rule of thumb (again, ask an AME if in doubt)

2. Hazardous Attitudes

A. Anti-Authority – "Don't tell me"
   i. People who don't like to be told what to do.
   ii. Antidote - Follow the rules. They are usually right.
B. Impulsivity - "Do it Quickly"
   i. The attitude of people who feel the need to something, anything, immediately. They may not stop to think about what they're going to do, or consider the alternatives
   ii. Antidote – Not so fast. Think first
C. Invulnerability – "It won't happen to me"
   i. People who believe that accidents happen to others, but never to them. These people tend to take more chances and be riskier.
   ii. Antidote – It could happen to me
D. Macho – "I can do it"

i. Pilots who are always trying to prove that they are better than anyone else and try to prove themselves by taking risks to impress others.
ii. Antidote – Taking chances is foolish

E. Resignation – "What's the use?"
   i. Pilots who do not see themselves as being able to make a great deal of difference. The pilot will leave the action to others, for better or worse.
   ii. Antidote – I'm not helpless. I can make a difference

3. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. Fly first!
      a. Aviate, Navigate, Communicate
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
   iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
      a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Loss of Situational Awareness
   i. Understand the human factors that can influence your ability to fly and know how to counter them
   ii. Admit the loss of situational awareness. If there's another pilot, let him or her 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 and altitude; if lost, climb to a safe altitude and maintain straight and level, etc.) and then solve the problem
   iii. Fly First. Aviate, Navigate, Communicate.

C. Improper Task Management
   i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
      b. Safety is your number one priority
         - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
      a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, and find a way to catch up
      a. If more time is needed, go around, find somewhere to hold/circle, or slow down
      b. Ask for assistance, if possible
      c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Describe symptoms, recognition, causes, effects, and corrective actions for at least three of the conditions listed in K1a through K1k above.
2. Perform self-assessment, including fitness for flight and personal minimums, for actual flight or a scenario given by the evaluator.

PREFLIGHT PROCEDURES

II.A. Preflight Assessment

This lesson is based off the PAVE acronym, used to mitigate risk by dividing it into 4 categories to review prior to every flight. **P**ilot, **A**ircraft, En**V**ironment, and **E**xternal Pressures

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Aviation Weather (AC 00-6), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Pilot Self-Assessment**
   A. IMSAFE – One of the best ways single pilots can mitigate risk. Used to determine physical and mental readiness for flying:
      i. Illness – Symptoms?
      ii. Medication – Taking any?
      iii. Stress – Family, money, relationships, work, etc.
      iv. Alcohol – Been drinking?
      v. Fatigue – well rested?
      vi. Eating – properly nourished? (Or, emotion. Is there anything that should prevent you from flying?)
      vii. Basically, is there anything physical, mental, or emotional that should prevent you from flying?
2. **Determining that the Aircraft to be Used is Appropriate and Airworthy**
   A. Appropriate
      i. Ensure that the aircraft is capable for the mission
         a. What do you need from the aircraft to accomplish the desired flight?
         b. Consider the passenger and cargo load, the aircraft's range vs the desired leg length, the equipment and capabilities required vs what's onboard
         c. Consider the runways available for the trip, the altitudes needed, etc.
      ii. Are you familiar with the aircraft?
         a. Do you have enough time to be competent in the aircraft and its systems/performance?
         b. Are you (and your instructor) confident in your abilities to fly the aircraft?
   B. Airworthy
      i. See Airworthiness Requirements
   C. Safe for Flight
      i. In the same way as a current pilot may not be a proficient pilot (doing 3 takeoffs and landings in the past 90 days probably doesn't make a pilot proficient in all aspects of flying), an aircraft is airworthy aircraft may not necessarily be safe for flight
         a. Be sure the aircraft is well maintained and capable of safe operation
         b. Fly with people/operations you trust
   D. What limitations will the aircraft impose upon the trip? Ask the following questions:
      i. Is this the right aircraft for the flight?
      ii. Am I familiar with, and current in this aircraft?
         a. Aircraft performance figures and the AFM are based on a brand-new aircraft flown by a professional test pilot. Keep that in mind while assessing personal and aircraft performance.
      iii. Is this aircraft equipped for the flight?
         a. Instruments? Lights? Navigation and communication equipment adequate?
      iv. Can this aircraft use the runways available for the trip with an adequate margin of safety under the conditions to be flown?

v. Can this aircraft carry the planned load?
vi. Can this aircraft operate at the altitudes needed for the trip?
vii. Does this aircraft have sufficient fuel capacity, with reserves, for trip legs planned?
viii. Does the fuel quantity delivered match the fuel quantity ordered?

3. The Aircraft Preflight

A. Once you're sure the aircraft can handle the mission, perform a preflight inspection to ensure it is airworthy and safe to fly
   i. The ACS wants the student to know which items must be inspected, the reasons for checking each item, how to detect defects, and the associated regulations. Since this will vary between aircraft, we won't try to answer that question, other than saying the manufacturer's preflight in the POH should be accomplished as directed.
      a. In terms of regulations in regards to airworthy aircraft and required operational equipment, refer to: I.B. Airworthiness Requirements
      b. Ensure the aircraft is legally airworthy: the proper inspections are completed and recorded (they must be recorded and signed off, don't let anyone tell you it's been done and not to worry about it), and the required equipment is operational
   ii. Make sure the required fuel load is onboard as well

4. Environmental Factors that could affect the Flight Plan

A. Once airborne (or prior to takeoff), various factors can affect the planned route of flight. Flying is a continual process of decision making. If things change, adapt to the new situation.
B. Weather
   i. As previously discussed, weather can cause a lot of problems as a Private Pilot. Always get a thorough weather briefing and have a backup plan in the case that you cannot get into the desired airport or continue on your desired route.
      a. Pilots should set their own personal minimums, especially when it comes to weather.
   ii. As pilots evaluate the weather for a particular flight, they should consider the following:
      a. What is the current ceiling and visibility?
         - In mountainous terrain, consider having higher minimums for ceiling and visibility, particularly if the terrain is unfamiliar.
      b. Consider the possibility that the weather may be different than forecast. Have alternative plans and be ready and willing to divert, should an unexpected change occur.
      c. Consider the winds at the airports being used and the strength of the crosswind component.
      d. If flying in mountainous terrain, consider whether there are strong winds aloft.
         - Strong winds in mountainous terrain can cause severe turbulence and downdrafts and be very hazardous for aircraft even when there is no other significant weather.
      e. Are there any thunderstorms present or forecast?
      f. If there are clouds, is there any icing, current or forecast?
         - What is the temperature/dew point spread and the current temperature at altitude? Can descent be made safely all along the route?
      g. If icing conditions are encountered, is the pilot experienced at operating the aircraft's deicing or anti-icing equipment?
         - Is this equipment in good condition and functional? For what icing conditions is the aircraft rated, if any?
C. Terrain
   i. Evaluation of terrain is another important component of analyzing the flight environment.
      a. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

    b. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  ii. Terrain can lead to potentially unanticipated factors in flight
    a. Turbulence – strong winds and mountains can, in certain circumstances, lead to turbulence (mountain waves, for example, can be violent)
    b. Often times clouds form above high terrain when warm, moist air is forced upward by the mountain and cooled
      - Have a plan to divert, change altitudes, change the route, etc. in the case that you encounter any of these
        - a How will this affect the rest of the flight plan? For example, if the route or altitude changes will you have fuel to continue to the original destination?
    c. If the temperature is higher than you planned the aircraft may not have the climb performance to clear the terrain
  iii. Day vs Night flying over terrain
    a. Maybe a personal minimum is to only fly over high terrain during daylight
  iv. Ensure you are flying at safe altitudes
    a. Use VFR, and IFR charts during planning
    b. Use MEF (Maximum Elevation Figures) to minimize chances of collision with terrain or other obstacles
D. Route Selection
  i. The route may have to change for various reasons as well
    a. Weather would be the most common reason as a VFR pilot
      - Clouds, low visibility, turbulence, storms, strong winds, etc. can influence your route
    b. TFR's, Restricted Areas, other airspace
      - Hopefully you were aware of TFRs a few days before the flight, but TFRs can pop up sometimes with little notice (you may already be airborne) for things such as firefighting, or some sort of military activity
      - If a Restricted area or MOA happens to be active, it can greatly affect your route
        - a Plan ahead, use the sectional to see if the area is expected to be active. Plan to go around it, if it doesn't happen to be active then proceed through it.
          1. Plan for the worst case, accept shortcuts (if you're prepared and comfortable with them)
    c. If the flight was originally planned during the day but had to be delayed until night your route may be affected for navigation purposes, airports being closed, airport lighting requirements, etc.
E. Obstructions
  i. Study the departure airport, route of flight, alternate airports, and destinations. Be aware of any potential obstructions to the planned flight and have a plan to mitigate them
    a. For example, if there are tall radio antennas to the North of the airport, plan an approach from a different direction.
  ii. Obstructions don't necessarily have to be terrain en route or near an airport, obstructions can include various other parts of the flight, such as:
    a. Airspace, airspace closures, TFRs, NOTAMs etc.
    b. The airport environment
      - Runway length, lighting capabilities (are you flying at night?), airport operating hours, fuel availability, etc.
    c. Passengers or even you, the pilot could be an obstruction

- People may get sick or scared. Passengers may show up late
- Use the IMSAFE acronym to be sure you're OK to fly
- Consider any other reason, you as the pilot could be an obstruction to the flight

iii. Flying is a continual decision-making process. Anticipate as much as you can and adapt to the rest.

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:
*See above for risk management of all the factors

1. **Pilot**
   A. The pilot is one of the risk factors in a flight
      i. Ask yourself, "Am I ready for this trip?" in terms of experience, recency, currency, physical and emotional condition
   B. Use the IMSAFE checklist
2. **Aircraft**
   A. See Section 2 above for questions to ask to mitigate the risk associated with the aircraft. If the aircraft is not capable for whatever reason, do not fly it
3. **Environment**
   A. Weather
      i. A good portion of risk management was discussed above in part 4B, the main points are to set and maintain personal weather minimums based on experience, competence, safety and comfort and to get a thorough weather briefing for the entire flight – know what to expect and have a backup plan for when things change
   B. Airports
      i. Review each intended and potential airport thoroughly. Consider:
         a. What lights are available at the destination and alternate airports?
            - VASI/PAPI or ILS glideslope guidance? Is the terminal airport equipped with them? Are they working? Will the pilot need to use the radio to activate the airport lights?
         b. Check the Notices to Airmen (NOTAM) for closed runways or airports.
            - Look for runway or beacon lights out, nearby towers, etc.
         c. Choose the flight route wisely. An engine failure gives the nearby airports supreme importance.
         d. Are there shorter or obstructed fields at the destination and/or alternate airports?
      ii. Remember FAR 91.103: Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight.
   C. Airspace
      i. Review and be familiar with all airspace when planning the route
         a. Know what airspace you will transition, what airspace you will avoid, operating requirements and restrictions, active days and times (if applicable), who you need to talk to in regards to the airspace, etc.
      ii. If the trip is over remote areas, is there appropriate clothing, water, and survival gear onboard in the event of a forced landing?
      iii. If the trip includes flying over water or unpopulated areas with the chance of losing visual reference to the horizon, the pilot must be prepared to fly IFR.
      iv. Check the airspace and any temporary flight restriction (TFRs) along the route of flight.
   D. Terrain and Obstacles

        i. As with the rest of the factors mentioned, be familiar with the terrain and obstacles (towers, antennas, etc.) along your route
            a. Determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
            b. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles
        ii. Plan Ahead!

4. **External Pressures**
    A. External Pressures are influences external to the flight that create a sense of pressure to complete a flight, often at the expense of safety.
    B. Examples include:
        i. Someone waiting on you to pick them up
        ii. A passenger you don't want to disappoint
        iii. The desire to demonstrate pilot qualifications or impress someone
        iv. The desire to satisfy a personal goal
            a. Get-Home-Itis
        v. A general goal-completion attitude
        vi. Pride
    C. Managing External Pressures
        i. The use of personal SOPs (Standard Operating Procedures)
            a. The goal is to supply a release for the external pressures by:
                - Allowing extra time on a trip for potential delays such as a fuel stop or weather
                - Have alternate plans for a late arrival of make backup airline reservations for must-be-there trips
                - Plan to leave early enough to allowing driving in the case that the flight is no longer an option
                - Know how to communicate delays to those who need to know
                - Manage passengers' expectations
                    a Make sure they understand that safety comes first
                - Eliminate pressure to return home
                    a Carry an overnight bag to help alleviate this pressure
        ii. Be ready to accept delays and have a backup plan (even if that means staying put for a night)

5. **Aviation Security Concerns**
    A. Airport Procedures
        i. Follow the local airport procedures. This may include, limited access entry to the airport (codes, gates, etc.), certain entry and exit points to and from the flight ramp, etc.
            a. Be aware of others not following the procedures or attempting to circumvent them
    B. If you see something, say something
        i. Be vigilant, if something doesn't look right, it probably isn't
        ii. Be aware of people asking a lot of suspicious questions (especially in regards to entry, airport monitoring, access to aircraft, etc.)
    C. The main idea is to be alert, and report suspicious activity

SKILLS

The applicant demonstrates the ability to:

1. Inspect the airplane with reference to an appropriate checklist.
2. Verify the airplane is in condition for safe flight and conforms to its type design.

II.B. Flight Deck Management

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers (AC 120-71), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Passenger Briefing Requirements**
   A. Safety Belts
      i. FAR 91.107: Each person must be briefed on how to fasten and unfasten the safety belt/harness
         a. You cannot taxi, takeoff, or land without notifying/ensuring each person has fastened their safety belt
   B. Emergency Procedures
      i. A passenger briefing on the proper use of safety equipment and exit info must also be done
         a. Inform passengers what should be done before and after an off-airport landing
         b. Ensure all passengers can open all exit doors and unfasten safety belts
      ii. Departure Plan
         a. Runway available, Runway Required, Emergency procedures during takeoff
2. **Use of Appropriate Checklists**
   A. The checklist is an aid to the memory and helps ensure that critical items necessary for the safe operation of aircraft are not overlooked or forgotten
      i. However, checklists are useless if the pilot is not committed to its use
   B. The importance of consistent checklist use cannot be overstated
   C. At a *minimum*, use checklists for:
      i. Preflight, before engine start, engine starting, before taxiing, before takeoff, after takeoff, cruise, descent, before landing, after landing, and engine shutdown and securing.
3. **Requirements for Current and Appropriate Navigation Data** (AIM 1-1-17)
   A. Although there is no specific FAR requiring the pilot to carry current charts, it is still highly recommended, especially based on the following:
      i. FAR 91.103: Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight.
      ii. The AIM in section 5-1-1 states that, "Pilots are urged to use only the latest issue of aeronautical charts in planning and conducting flight operations."
      iii. In section 5-1-2, the AIM provides a list of suggested practices, one of which is, "Use current charts."
      iv. From an FAA Aviation News article:
         a. "If a pilot is involved in an enforcement investigation and there is evidence that the use of an out-of-date chart, no chart, or an out-of-date database contributed to the condition that brought on the enforcement investigation, then that information could be used in any enforcement action that might be taken."
      v. So, although current charts are not required, they are highly recommended for safety and current pertinent knowledge.
   B. GPS Navigation Data
      i. Check the currency of the database.
      ii. Databases must be updated for IFR operations and should be updated for all other operations. However, there is no requirement for databases to be updated for VFR navigation.

    a. It is not recommended to use a moving map with an outdated database in and around critical airspace.
    b. Pilots using an outdated database should verify waypoints using current aeronautical products; for example, Chart Supplement U.S., Sectional Chart, or En Route Chart.

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Improper Use of Systems or Equipment, to Include Automation and Portable Electronic Devices**
    A. Automation is a great tool, when it is used properly
        i. A proper understanding of the automation's capabilities and procedures is required
        ii. Used incorrectly, automation can lead to an unsafe situation
            a. Don't let automation distract you from flying the airplane, if it's not doing what you want, fix it, or turn it off and hand fly
    B. Portable Electronic Devices
        i. FAR 91.21 - No person may operate, nor may any operator or pilot in command of an aircraft allow the operation of, any portable electronic device on any of the following U.S.-registered civil aircraft:
            a. Aircraft operated by a holder of an air carrier operating certificate or an operating certificate; or
            b. Any other aircraft while it is operated under IFR
        ii. Although the regulations only specifically prohibit PEDs on IFR flights, PEDs should only be used in a way that increases situational awareness in the aircraft.
            a. Do not become distracted by any PED. Fly the airplane.
    C. Technology can be a great tool to increase situational awareness, and competence in the cockpit, but used inappropriately, it can quickly become a distraction
        i. Always divide time between the aircraft and any technology in use (tablet, navigation apps, GPS, weather radar, etc.)
        ii. If it doesn't increase situational awareness/competence it doesn't belong in the cockpit
            a. For example, games on your tablet, social media, etc. or a system/tool you are not competent with (don't become distracted)
2. **Flying with Unresolved Discrepancies**
    A. Probably unsafe and potentially illegal (un-airworthy)
        i. Depending on the situation, flying with an unresolved discrepancy can be dangerous. Get the aircraft fixed, or don't fly.
            a. If the discrepancy directly affects the aircraft's airworthiness, then the aircraft is no longer legal to fly
    B. Put safety first

SKILLS

The applicant demonstrates the ability to:

1. Secure all items in the flight deck and cabin.
2. Conduct an appropriate pre-takeoff briefing, to include identifying the PIC, use of safety belts, shoulder harnesses, doors, sterile flight deck, and emergency procedures.
3. Properly program and manage aircraft automation.

II.C. Engine Starting

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Starting under Various Conditions**
   - A. Cold Weather
     - i. Oil can congeal (become thick)
       - a. Pull the prop through several times to loosen the oil
         - This saves battery energy, but before moving the propeller ensure the ignition/mag is OFF, throttle CLOSED, Mixture CUTOFF
           - a An accidental start could cause severe injuries or death
       - b. Preheat the engine (usually required below 0°F and recommended below 20°F)
     - ii. Unheated Engine
       - a. Icing over the sparkplug electrodes – The only remedy is heat
         - The engine will fire and quit; there is enough combustion to cause the ice to melt into water in the cylinders
           - a The water condenses, freezes and shorts out the sparkplugs
     - iii. Starting
       - a. Prime the engine with fuel first (over-priming can result in an aircraft fire – AC 91-13)
       - b. After start, allow the engine to idle at low RPMs to allow the oil to warm and circulate
         - Engines may quit during long idling since sufficient heat isn't produced to keep the sparkplugs from fouling
     - iv. Cold Weather Ops Advisory Circular
   - B. Hot Weather
     - i. Cylinders tend to become flooded and the Flooded Checklist should be used to clear the them
     - ii. Fuel injected engines may have difficulty starting due to vaporization
       - a. When shut down, the air temperature in the cowling goes up vaporizing fuel which creates a vapor lock
         - The electric fuel pump is used to move fuel into the lines, cooling them and removing vapors
       - b. VERY HOT – Vapor problems may be evident after start due to insufficient slipstream cooling
         - Monitor the fuel flow gauge for a fluctuation and use the electric pump to purge the system
2. **Starting the Engine(s) by use of External Power**
   - A. Follow the external power starting procedures as described in the flight manual
     - i. Always use the appropriate checklist
3. **Engine Limitations as they Relate to Starting**
   - A. Understand and abide by the limitations associated with engine starting as described in the flight manual

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Propeller Safety**

A. Normal Start
   i. Position the airplane properly
   ii. Set the Parking Brake
   iii. Look in all directions to be sure nothing is or will be in the vicinity of the propeller (and propeller blast)
   iv. Strobe Lights/Anti-collision lights should be turned on prior to start (at night use position lights too)
   v. Always call “CLEAR” out of the side window and wait for a response from someone who may be nearby
   vi. Keep one hand on the throttle to allow prompt response
B. Hand Propping Safety
   i. Basic requirements BEFORE attempting a hand prop
      a. Do not hand prop unless two people, both familiar with hand propping techniques are available
         - Never allow a person unfamiliar with the controls to occupy the pilot’s seat when hand propping
      b. The person pulling the propeller blades through directs all activity and is in charge of the procedure
         - Chocks can be an additional precaution, or tie down the tail (Be careful removing them)
      c. The ground surface near the prop should be stable and free of debris (otherwise relocate)
         - Loose gravel, wet grass, mud, etc. might cause the person pulling the prop to slip into the blades
      d. Both participants should discuss the procedure and agree on voice commands and expected action
   ii. Engine Starting Set-up
      a. The fuel system/engine controls (pump, primer, throttle, mixture) should be set for a normal start
      b. Check to ensure the ignition/magneto switch is OFF
      c. The descending prop blade should be rotated to a position slightly above horizontal
      d. The person doing the propping should face blade squarely and stand less than an arm’s length away
         - Too far away and it would be necessary to lean forward in an unbalanced condition
   iii. Procedures and Commands for Hand Propping
      a. Person out front says, “GAS ON, SWITCH OFF, THROTTLE CLOSED, BRAKES SET”
         - Person IN ensures - Fuel: ON, Mixture: RICH, Ignition: OFF, Throttle: CLOSED, Brakes SET, and repeats
      b. Person out front checks the brakes by pushing on the prop
      c. Person out front, after pulling the prop through to prime the engine says, “BRAKES AND CONTACT”
         - Person in the pilot’s seat checks the brakes SET and turns the ignition switch ON, then repeats
      d. The propeller is swung by forcing the blade downward rapidly as hard as possible
         - Push with the palms as fingers may result in being drawn into the blades if the engine misfires
      e. If it does not start, the prop should not be moved until certain the ignition/magneto switch is OFF

SKILLS

The applicant demonstrates the ability to:

1. Position the airplane properly considering structures, other aircraft, wind, and the safety of nearby persons and property.
2. Complete the appropriate checklist.

II.D. Taxiing

References: Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Risk Management Handbook (FAA-H-8083-2), Parts 91 and 135 Single Pilot, Flight School Procedures During Taxi Operations (AC 91-73), AIM, POH/AFM, Chart Supplements

KNOWLEDGE

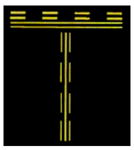
The applicant demonstrates understanding of:

1. **Airport Information Resources**
   - A. Chart Supplements (Formerly called the A/FD – Airport/Facilities Directory)
     - i. Contain data on public and joint use airports, seaplane bases, heliports, VFR airport sketches, NAVAIDs, communications data, weather data, airspace, special notices, and operational procedures
     - ii. Includes data that cannot be readily depicted in graphic form: e.g., airport hours of operation, types of fuel available, runway data, lighting codes, etc.
   - B. Airport Diagrams
     - i. Always have an airport diagram on hand for each intended and alternate airport in your flight plan
     - ii. Always know where you are and where you're going
       - a. Review the airfield NOTAMs and reflect any changes on the airport diagrams (for example: taxiway closures)
   - C. Other Information
     - i. In addition to the Chart Supplement, and taxi diagrams, airport information is now readily available on various apps
     - ii. Taxi diagrams can be printed online or found in the Terminal Procedures Publication
     - iii. NOTAMs should be reviewed prior to every flight for the airports in the flight plan
2. **Taxi Instructions/Clearances**
   - A. Approval must be obtained prior to moving onto the movement area while tower is in operation
   - B. A clearance must be obtained prior to crossing ***any runway***; ATC will issue an explicit clearance for ***all*** runway crossings
     - 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. Any clearance to enter a specific runway
     - iii. Any instruction to hold short of a specific runway
   - E. Before taxiing, ask yourself whether the instructions make sense – Contact ground if they don't
     - i. Repeat all clearances back and understand airport signs and markings
     - ii. Have an airport diagram on hand; always know where you are and where you're going
3. **Airport Markings, Signs, and Lights**
   - A. 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 intersection

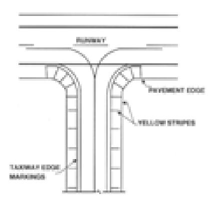
ii. Taxiway Centerline Marking
a. Normal Centerline
- Purpose - Provide a visual cue to permit taxiing along a designated path
    - a Markings - A single continuous yellow line that is 6" - 12" wide

b. Enhanced Centerline



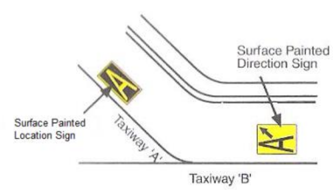
- Purpose - Same as above but at larger commercial airports to warn that a runway hold position marking is being approached and unless cleared to cross, the aircraft should prepare to stop
- Markings - A parallel line of yellow dashes on either side of the normal taxiway centerline
    - a Centerlines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

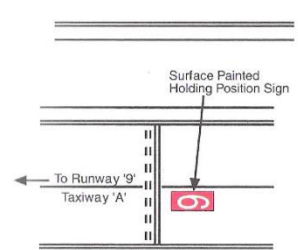


iv. Taxi Shoulder Markings
a. Purpose - Paved shoulders prevent erosion but they may not support aircraft
b. Markings - Taxiway edge markings will usually define this area
- If confusion exists to the side of use, yellow shoulder markings are used

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

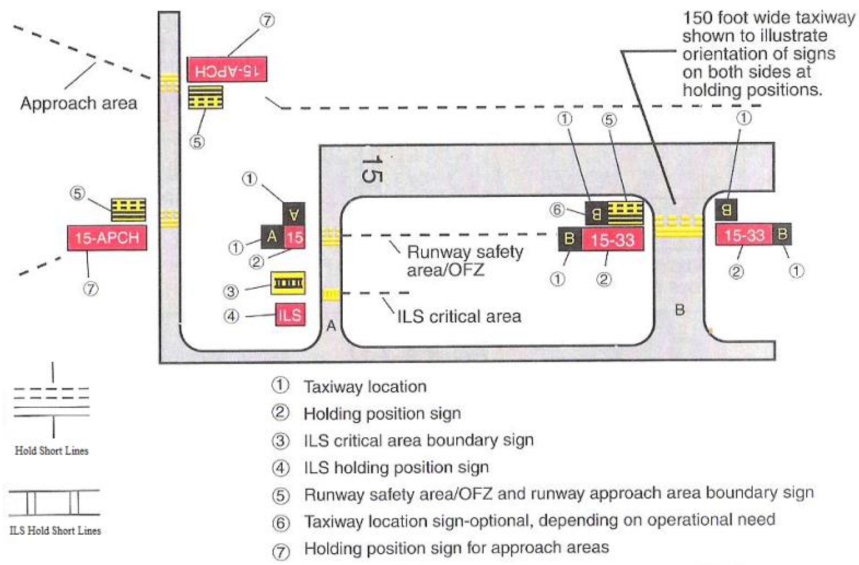


vii. Geographic Position Markings
a. Purpose - Identifies aircraft location during low visibility operations
b. Markings - Left of the taxiway centerline in the direction of taxiing

- 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

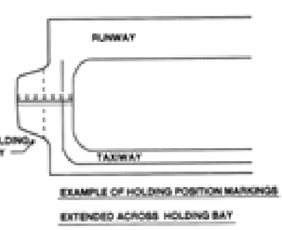
- Designated with either a number or a number and a letter
    - a Number corresponds with consecutive position on the route

viii. Holding Position Markings

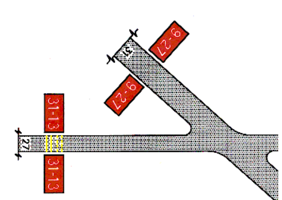


a. General

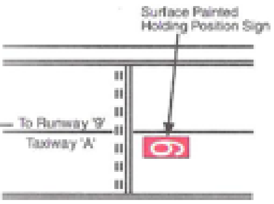
- Show where an aircraft is supposed to stop when approaching a runway (hold on the solid side)
- 4 yellow lines (2 Solid/2 Dashed) spaced 6” or 12” apart across the width of the taxiway or runway
- 3 locations where runway hold lines are encountered: [1]Taxiways; [2]Runways; [3]Approach Areas
- Runway Holding Position Markings on Taxiways
    - a Purpose - Identify where to stop without a clearance onto the runway
        1. Always stop so that no part extends beyond the hold markers
        2. Don’t cross without clearance and separation at uncontrolled airports



- Runway Holding Position Markings on Runways
    - a Purpose - Only installed if normally used for LAHSO or taxiing operations
        1. Must stop before markings/exit prior to reaching the position
    - b Markings - Sign (white inscription/red background) next to hold markings
        1. Markings are placed on the runway prior to the intersection
- 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)
        1. Purpose - Hold aircraft when the ILS critical area is being protected
        2. Markings - 2 yellow solid lines 2’ apart joined by pairs of solid lines 10’ apart across the taxiway
- Holding Position Markings for Taxiway/Taxiway Intersections
    - a Purpose - Installed on taxiways where ATC normally holds aircraft short of a taxiway intersection



b. Markings - Single dashed line extending across the width of the taxiway
    1. If requested to hold short of a taxiway without markings, provide adequate clearance from the taxiway

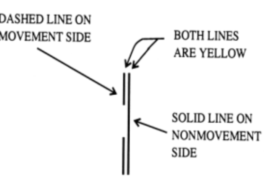


- Surface Painted Holding Position Signs
    a. Purpose - Used to supplement the signs located at the holding position
        1. Normally used when the width of the holding position on the taxiway is greater than 200'
    b. Markings - Red background/white inscription, left of center, on the holding side, prior to hold lines

i. Other Markings

a. Vehicle Roadway Markings
- Purpose - Used to define a path for vehicle operations on or crossing areas also intended for aircraft
- Markings - White solid line delineates each edge and a dashed line separates lanes
    a. In lieu of the solid lines, zipper markings may be used to delineate edges

b. VOR Receiver Checkpoint Markings
- Purpose - Allow the pilot to check aircraft instruments with navigational aid signals
- Markings - A painted circle with an arrow in the middle (arrow is aligned toward the facility)
    a. Located with a sign on the apron/taxiway
    b. Sign shows the VOR station ID letter, course for the check, and DME data (if necessary)
    c. Black letters/numerals on a yellow background

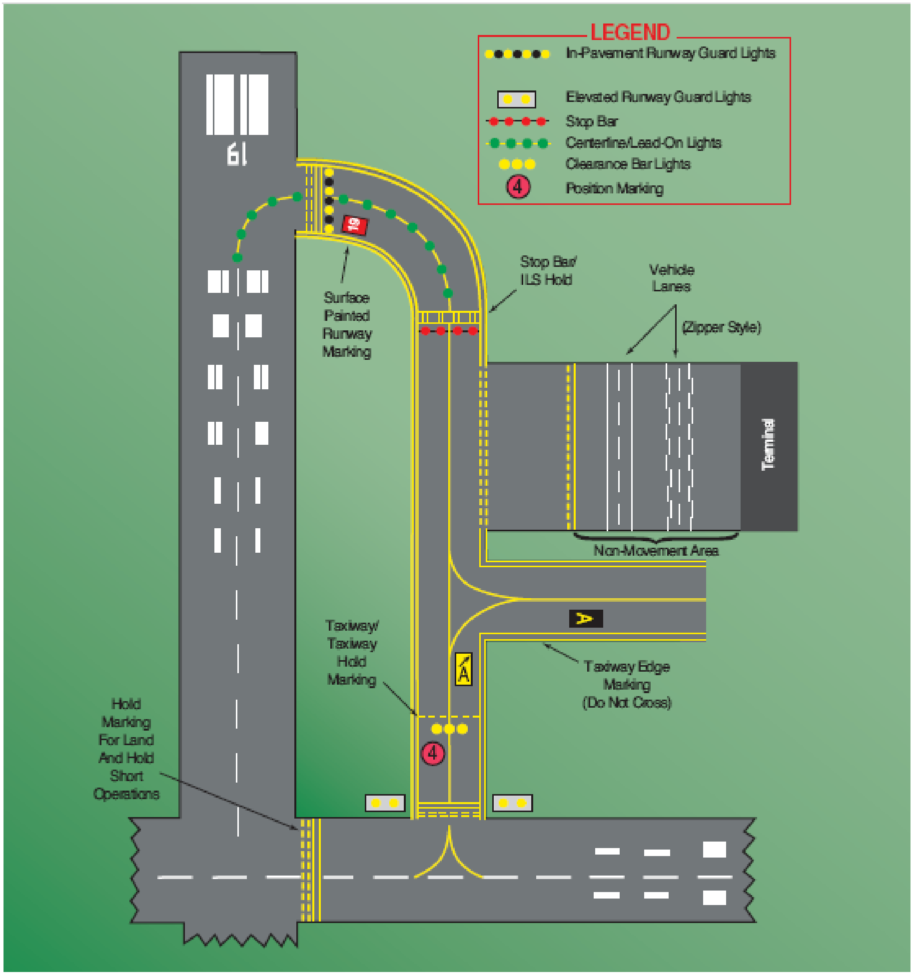


c. Nonmovement Area Boundary Markings
- Purpose - Delineates the movement area (The area under air traffic control)
- Markings - 2 yellow lines (one solid and one dashed) 6" in width
    a. Solid line is the nonmovement area side, the dashed line is the movement area side

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

e. Temporarily Closed Runways and Taxiways
- Purpose - To provide a visual indication to pilots that a runway is temporarily closed
- Markings - Yellow crosses are placed on the runway at each end
    a. A raised lighted yellow cross may be placed on each end of the runway instead
    b. 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
        1. Check NOTAMs and the ATIS for information
    c. Closed taxiways are treated as hazardous areas and blockaded; no part of the aircraft may enter

1. As an alternative, a yellow cross may be installed at each entrance to the taxiway

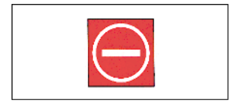


B. Airport Signs
   i. General
      a. Six types of signs installed on airfields
         - Mandatory Instruction; Location; Direction; Destination; Information; Runway Distance Remaining
   ii. Mandatory Instruction Signs
      a. Purpose - Denote entrance to runway or critical area/area where aircraft 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

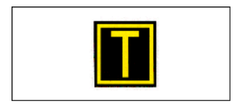
- No Entry Sign
  - a Prohibits an aircraft from entering an area
  - b Typically, on a taxiway intended to operate in one direction or vehicle intersections that may be mistaken as a taxiway/movement surface



iii. Location Signs

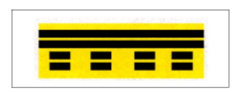
a. Purpose - Identify either a taxiway or runway on which the aircraft is located
- Other location signs provide a visual cue to assist in determining when an area has been exited

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

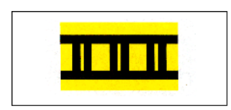


c. Runway Location Sign
- Purpose - Complement compass info; typically installed where the proximity of runways to one another could cause confusion as to which runway the pilot is on
- Markings - Black background with a yellow inscription

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 the designations of intersecting taxiways leading out of an intersection
  - a Designations and their arrows are arranged clockwise from the 1st taxiway on the pilot's left

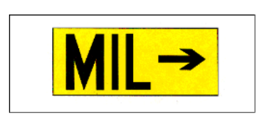
b. Markings - Yellow background/black inscription with an arrow indicating the turn direction

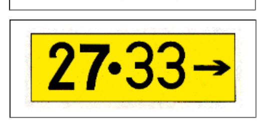
v. Destination Signs

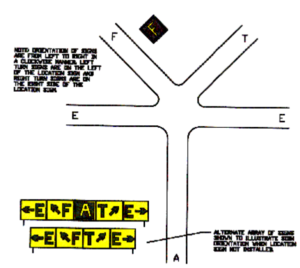
a. Purpose - Indicates a destination on the airport

b. Destinations commonly shown are

• Runways	• Civil Aviation Areas
• Aprons	• Cargo Areas
• Terminals	• International Areas
• Military Areas	• FBOs







c. Markings - Yellow background/black inscription indicating a destination on the airport
- 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

b. Markings - Yellow Background with a black inscription

vii. Runway Distance Remaining Signs

a. Purpose - Used to inform the pilot the amount of distance remaining on the runway
    - The number on the sign indicates the thousands of feet of landing runway remaining

b. Markings - Black background/white numeral inscription

viii. Make sure to know the meaning and purpose of all the signs and markings
    - If unsure, stop and ask ATC for clarification

C. Lighting

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. 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

vii. 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

c. Bidirectional (i.e., 1 side emits light for the lead-on function the other for the lead-off)

4. Visual Indicators for Wind

C. Wind cones
    i. Be familiar with the various wind direction indicators that are used at airports
D. Blowing grass, smoke, water, leaves, etc.
    i. Simply seeing the direction from which the wind is blowing can provide an indication as to how to position the flight controls
E. Heading Bug
    i. Set the heading bug to the wind direction reported on the airport weather information (ATIS, AWOS, ASOS)

5. **Aircraft Lighting**
    C. At a minimum, use taxi lights when taxiing
        i. At night, use the strobe and position lights as well, be careful not to blind other pilots while taxiing
            a. Strobes especially can be very annoying for other pilots, if possible, turn them off to help others (if it doesn't affect safety)
6. **Appropriate Flight Deck Activities**
    C. Route Planning
        i. Once you receive the taxi clearance from ATC review it on the airport diagram
        ii. If you have any issues or questions, ask ATC before proceeding
    D. Hot Spots
        i. Review and brief the hot spots shown on the airport diagram
            a. These are spots that have a higher likelihood of an aircraft incident, be extra cautious
            b. Brief how you plan to mitigate the hazard associated with the hot spot
    E. ATC Communications
        i. Obtain and read back your taxi clearance, including any runway crossing or hold short instructions
        ii. Listen and read back any updates or changes to your clearance while taxiing
        iii. If you're ever unsure of an ATC instruction, ask for clarification
            a. If necessary, stop the aircraft (as long as it's safe to do so) and obtain clarification
7. **Safe Taxi at Towered and Non-Towered Airports**
    A. Towered Airports
        i. As mentioned above, always read back your taxi clearance, and if ever unsure of any instruction, ask for clarification
        ii. If the pilot is unfamiliar with the airport or for any reason confusion exists as to the correct taxi routing, a request may be made for progressive taxi instructions which include step−by−step routing directions
        iii. Be vigilant for other traffic and especially vigilant in and around hot spots
    B. Non-Towered Airports
        i. Announce your intentions on the CTAF frequency
        ii. Listen for other aircraft and build a picture of the traffic at the airport
        iii. Taxi defensively, don't expect the other aircraft to give way to you
            a. Also, don't guess, if you're unsure of a situation, talk to the other pilot and coordinate a safe outcome
    C. At All Airports
        i. Speed is controlled 1st with power and 2nd with brake pressure (use the toes to apply brakes evenly)
            a. Taxi as though the brakes are inoperative – At the speed of a fast walk
                - Primary speed requirement is safe, and under positive control (be able to stop, turn when desired)
            b. More power may be necessary to get the airplane moving than to keep it moving (reduce after start)
        ii. Maintaining Taxiway/Runway Alignment

a. Keep the centerline between your outside leg and the stick, this should keep the nose of the aircraft on the centerline
    - Adjust the sight picture as necessary if this sight picture does not work for you or the specific aircraft
b. Different aircraft will have different references in order to maintain centerline. Find one that works for you

iii. Situational Awareness to Avoid Runway Incursions
a. Always review and carry a taxi diagram
    - Understand and review the likely taxi route
        - a Check NOTAMs when preparing for the flight and mark the taxi diagram for any changes to the airport environment (closed taxiways, construction, etc.)
    - Be aware of hot spots shown on the diagram – be extra cautious
    - Always know where you are and where you're going
b. If you're lost or confused, ask for help
    - Request progressive taxi instructions if necessary

iv. Taxiing to Avoid Other Aircraft/Vehicles and Hazards
a. Always ensure clearance when taxiing by or around other aircraft, vehicles, or hazards
    - If you're unsure, stop! Get a wing walker or verify that you are in fact clear of the hazard
b. The airlines and Air Force have distance minimums to continue past another aircraft
    - Usually, at least 25' clearance to pass
    - If less than 25' (but no less than 10'), you can pass, but only with a wing walker
    - Never less than 10'
    - These minimums can likely be reduced for general aviation aircraft, but use the recommendations in the flight manual or set your own personal minimums
        - a Set a cone or have a person stand at different distances from the wing tip to find a visual reference to relate to the various distances so that you know how close you are to hazards when taxiing
c. Maintaining awareness of the location/movement of all other aircraft and vehicles is essential to safety
d. Visually scan the area, constantly looking for traffic/hazards (spend minimum time focused inside the cockpit)
    - If a checklist needs to be completed, or attention needs to be diverted from taxiing, wait until the aircraft is stopped
        - a In the case of an emergency, stop the aircraft immediately and proceed as required
e. Hazards of becoming distracted while taxiing
    - Distractions can be hazardous to yourself and other aircraft
    - Taxi first, accomplish checklists, etc. once fully stopped and in a safe place
f. Monitor the appropriate frequency
g. Apply the Right-of-Way rules and maintain adequate spacing (right-of-way is the same as in the air)
h. Don't create hazards - Ensure your wings will clear other planes and don't prop-wash others
i. Proceed at a cautious speed (a fast walk)
j. When yellow taxiway center lines are provided, they should be observed
k. Slow down before making a turn
    - Sharp, high speed turns place adverse loads on the gear and may result in a swerve or ground loop
l. Maintain a sterile cockpit

- Refrain from all nonessential activities during taxi
    - a There should be no checklists, conversations, phone calls/texting, etc.
- Hazards associated with failing to adhere to sterile cockpit procedures
    - a Distractions can be hazardous to yourself and other aircraft, wait until you are safely and fully stopped

8. **Entering or Crossing Runways**
    - A. A clearance must be obtained prior to crossing ***any runway***; ATC will issue an explicit clearance for ***all*** runway crossings
        - i. Any runway means ***any runway***: active, inactive, open, closed, etc.
    - B. If you're unsure, ask. Never cross the runway hold short lines without a clearance
9. **Night Operations**
    - A. Due to restricted vision, taxi speeds should be reduced
        - i. Don't taxi faster than a speed that will allow a stop within the distance you can clearly see
    - B. Use the landing/taxi lights as necessary
    - C. Do not use strobes or landing lights in vicinity of other aircraft
        - i. These can be distracting, and blinding to other pilots
    - D. Orientation
        - i. Airport Diagram (always have one out)
        - ii. Understand the taxiway markings, lights, and signs
10. **Low Visibility Operations**
    - A. Very similar to night operations
        - i. Don't taxi faster than a speed that will allow you to stop within the distance that you can clearly see
    - B. Lights may make visibility more difficult (taxi and landing lights may reflect off fog)
        - i. Turn them off if necessary
    - C. Tower Visibility
        - i. Tower may not be able to see you taxiing
        - ii. Be very cautious, listen to the radios to get an idea of where other aircraft currently are and where they're going
    - D. Orientation
        - i. Always have a taxi diagram, and review the route prior to moving the aircraft

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Inappropriate Activities and Distractions**
    - A. Your attention should be focused on the safely taxiing the aircraft
        - i. At this point, checklists should be completed
            - a. If checklists are not completed, or the taxi diagram hasn't been reviewed, or anything else hasn't been taken care of, you are not ready to taxi
            - b. Wait to obtain the taxi clearance, or if necessary, cancel the taxi clearance and finish all remaining tasks so that your full attention can be given to safely taxiing the aircraft
        - ii. Do not program the FMS, or input nav frequencies, this can wait until the aircraft is safely stopped
    - B. Passengers
        - i. Explain to passengers that during taxi there should be no conversation except that related to taxiing
    - C. Other aircraft
        - i. Pilots love watching other aircraft, be aware of where they are at, and don't get distracted by them

- D. Radio Communications
    - i. Turn off any unnecessary radio frequencies that may distract you from taxiing and communicating with ground control
- E. Cell Phones, tablets, technology
    - i. No texting, talking on the phone, checking email, checking anything during taxi
    - ii. Your focus needs to be on safely taxiing

2. Confirmation or Expectation Bias and Taxiing

- A. Listen to the instructions given by ATC
    - i. It's very easy to hear what you expect ATC to say
        - a. For example: You're at your home airport, you've always received the same taxi instructions to runway 27. Rather than listening to the instructions ATC gives you, out of habit you read back what you're used to hearing. This can cause safety issues if there's another aircraft on your normal route, construction, or a taxiway closure.
- B. Always read back the instructions ATC gives you, not what you expect to hear
    - i. Clarify the instructions with ATC if you're ever unsure

3. A Taxi Route or Departure Runway Change

- A. Taxi
    - i. Adjust the route as required based on the new instructions
        - a. Request a place to stop if necessary to assess/find the new route on the taxi diagram
        - b. Progressive taxi is an option if needed
- B. Takeoff
    - i. Before moving to the new runway, verify the route on the taxi diagram
    - ii. Before takeoff verify that the new runway is acceptable
        - a. Winds are within limits (crosswind, tailwind), runway length is sufficient (take into account the grade and any other important factors), runway width is sufficient, departure obstacles aren't a factor, etc.
    - iii. Take your time to become familiar with the change
        - a. This will not only affect your taxi and takeoff but also the departure procedure to get you on course, adjust as necessary

SKILLS

The applicant demonstrates the ability to:

1. Receive and correctly read back clearances/instructions, if applicable.
2. Use an airport diagram or taxi chart during taxi, if published, and maintain situational awareness
3. Position the flight controls for the existing wind conditions.
4. Complete the appropriate checklist.
5. Perform a brake check immediately after the airplane begins moving.
6. Maintain positive control of the airplane during ground operations by controlling direction and speed without excessive use of brakes.
7. Comply with airport/taxiway markings, signals, ATC clearances and instructions
8. Position the aircraft properly relative to hold lines.

II.F. Before Takeoff Check

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **The Purpose of Pre-Takeoff Checklist Items**
    A. The pre-takeoff checklist is a systematic procedure for making a check of the engine, controls, systems, instruments, and avionics prior to flight
        i. The idea is to find any problems before taking off
        ii. Procedures will vary greatly between aircraft. In general, follow the manufacturer's instruction laid out in the POH to know what to check, the reasons to check each item, how to detect a malfunction, and to ensure the aircraft is in a safe operating condition as recommended by the manufacturer
    B. Reasons for Checking each Item
        i. Since this will vary between aircraft, accomplish the manufacturer's preflight in the POH as directed.
    C. Detecting Malfunctions
        i. Malfunctions will also be detected per the manufacturer's limitations and instruction set forth in the POH
    D. Ensuring the Airplane is in Safe Operating Condition as Recommended by the Manufacturer
        i. Ensure the aircraft operates within all tolerances described in the POH

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

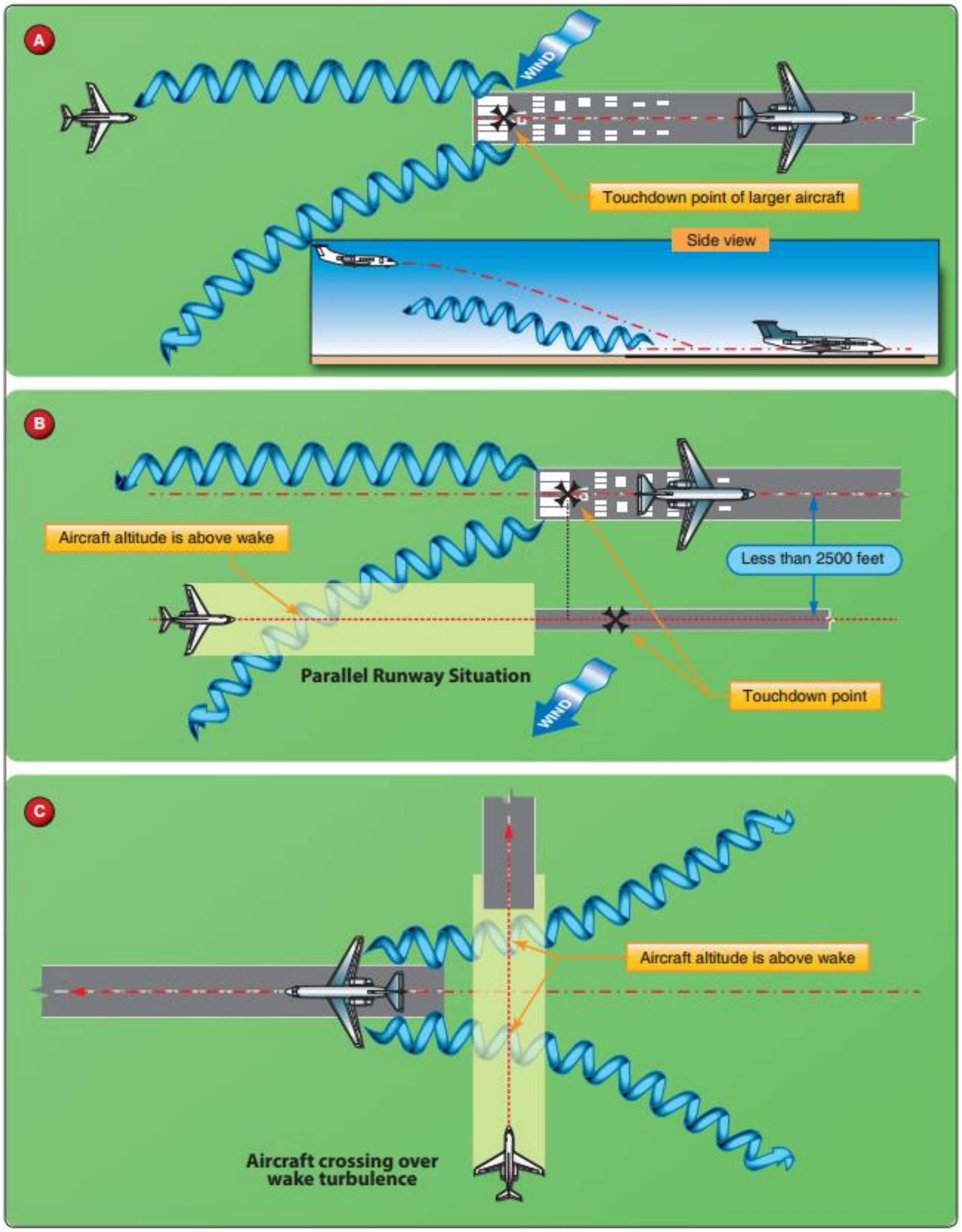
1. **Division of Attention While Conducting Pre-Flight Checks**
    A. While performing the run-up, the pilot must divide attention inside and outside the aircraft
        i. If the parking brake slips or if application of the toe brakes is inadequate the aircraft could move unnoticed if attention is fixed inside the aircraft
    B. Divide attention between your surroundings and the pre-flight checks
        i. Continue to monitor the appropriate frequency in the case ground or tower needs to get ahold of you
    C. During the engine run-up, be careful not to blow dirt, rocks, and debris into an aircraft, car, building, etc.
2. **Unexpected Runway Changes by ATC**
    A. Before moving to the new runway, verify the route on the taxi diagram
    B. Before takeoff verify that the new runway is acceptable
        i. Winds are within limits (crosswind, tailwind), runway length is sufficient (take into account the grade and any other important factors), runway width is sufficient, etc.
    C. Take your time to become familiar with the change
        i. This will not only affect your taxi and takeoff but also the departure procedure to get you on course, adjust as necessary
3. **Wake Turbulence**
    A. All aircraft generate wake turbulence during flight.
        i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
        ii. The vortices from larger aircraft pose problems to aircraft encountering them

        a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft

B. Wake Turbulence Recognition in the Terminal Area
    i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
    ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
        a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft

C. Wake Turbulence Resolution
    i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
        a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
        b. Crossing runways – cross above the larger jet's flight path

ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



SKILLS

The applicant demonstrates the ability to:

1. Review takeoff performance.
2. Complete the appropriate checklist.
3. Properly position the airplane considering other aircraft, vessels, and wind.

4. Divide attention inside and outside the flight deck.
5. Verify that engine parameters and airplane configuration are suitable.

AIRPORT BASE OPERATIONS

III.A. Communications, Light Gun Signals, and Runway Lighting Systems

References: 14 CFR part 91, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM

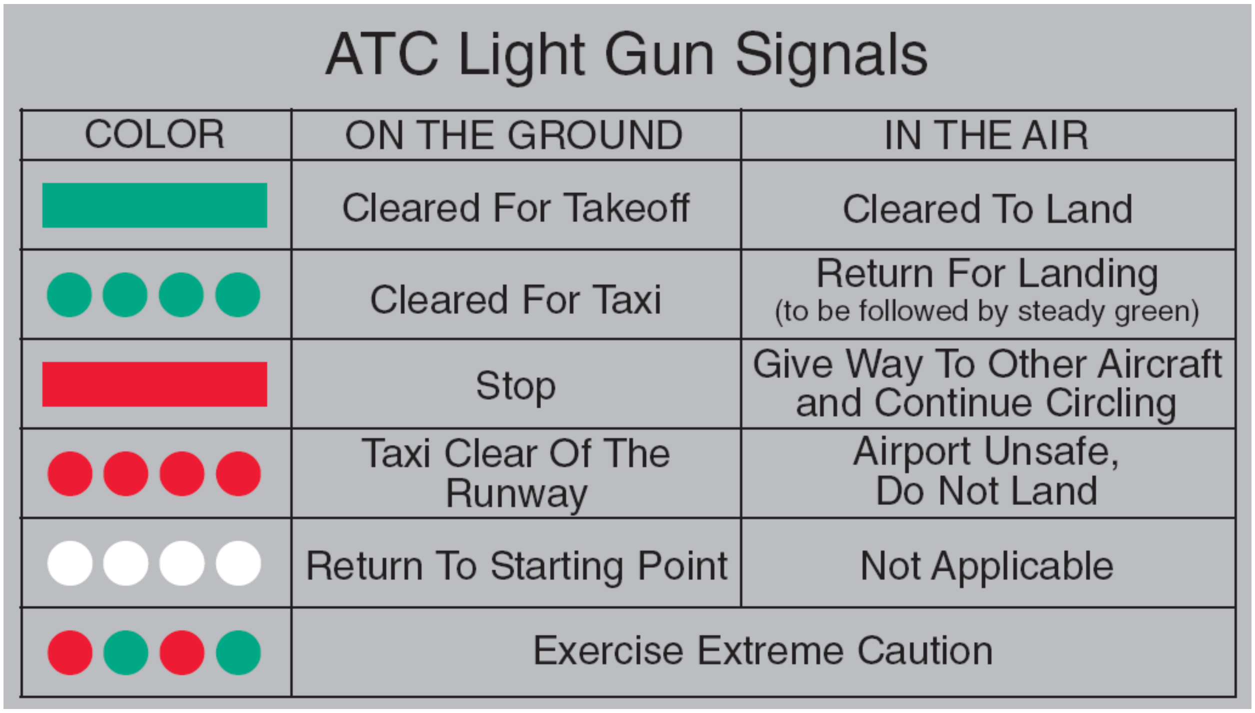
KNOWLEDGE

The applicant demonstrates understanding of:

1. **How to Obtain Proper Radio Frequencies**
    - A. Preflight Planning
        - i. Always plan ahead in regards to frequencies needed
        - ii. Look up the frequencies of the facilities you might use or need during the flight
            - a. This information can be found in the Chart Supplements, Sectional Charts, etc.
            - b. 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.
        - iii. One technique is to put all of this information in your Nav Log, preferably in the order you will use the frequencies to make things easy when flying
    - B. During flight, frequencies may need to be found - keep organized and attempt find them before they're needed
        - i. Know who you are calling, and what you're going to say before keying the microphone
    - C. The Chart Supplement (formerly called the A/FD) contains all pertinent frequencies within/around the airport(s) you are operating in
        - i. Weather, Tower/CTAF, Clearance Delivery, Ground, Unicom, Navaids, FSS, Approach/Departure
    - D. Charts provide frequencies as you navigate
        - i. Communications Boxes (FSS)
        - ii. Airport data lists tower/CTAF, Unicom, weather frequencies (ASOS, AWOS, or ATIS)
        - iii. VOR frequencies are shown in blue outlined boxes
        - iv. Class B, C, TRSA, and some radar approach frequencies are provided on sectional and terminal charts
    - E. Once in contact with controllers, frequencies will be provided to reach further controllers
    - F. One common error is the of improper frequencies
        - i. Caused by inadequate planning, misreading/mishearing frequencies, or mistuning the radio
        - ii. Double check and read frequencies out loud, also repeat frequencies when instructed to change
        - iii. Monitor the frequency before transmitting
    - G. Transmitting without waiting often results in stepping on someone else's communication and confusion
2. **Communication Procedures and ATC Phraseology**
    - A. Understanding is the single most important part of 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 when 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 (in the AIM) is very helpful in learning what certain words/phrases mean
    - B. Radio Technique
        - 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:
        i. Who you are calling (Chicago Center)
        ii. Who you are (Diamond 4TS)
        iii. Where you are (10 miles South of ______, 5,000')
        iv. What you want (Request flight following, or whatever you want)
    D. A common error is improper procedure and phraseology for radio communications
        i. Think before you transmit and understand the controller may be busy
        ii. Tailor your calls to match the controller's workload
    E. Use the Pilot/Controller Glossary to ensure correct, succinct radio calls

3. ATC Light Gun Signals



ATC Light Gun Signals

COLOR	ON THE GROUND	IN THE AIR
	Cleared For Takeoff	Cleared To Land
	Cleared For Taxi	Return For Landing (to be followed by steady green)
	Stop	Give Way To Other Aircraft and Continue Circling
	Taxi Clear Of The Runway	Airport Unsafe, Do Not Land
	Return To Starting Point	Not Applicable
	Exercise Extreme Caution	

    A. Know the light signals and their meanings
        i. Carry a copy of the light gun signals on your kneeboard (stressful situations can result in forgetting information or confusion)
    B. Practice light signals if possible
        i. Ask tower to shine the lights at you while on the ground and in the pattern

4. Transponders

    A. ATC radar facilities have both primary and secondary radar
        i. Primary Radar works on the principle of bouncing high powered microwave pulses off objects and detecting the reflected echo
            a. Limitations: Only reports azimuth and range (no alt), not great with small, composite aircraft, and limited by terrain and precipitation
        ii. Secondary Radar solves a lot of these limitations

a. Secondary radar depends on a transponder in the aircraft to respond to interrogations from a ground station
    - The pilot inputs a 4-digit code assigned by ATC into the transponder
    - Depending on the type of transponder, and the type of interrogation, the transponder sends back an identification code as well as altitude
        - a Mode A: Sometimes referred to as Mode3/A, it responds to an interrogation signal with the input transponder code
        - b Mode C: Equipped with an altitude encoder and altimeter. ATC will see the flight altitude on their radar screen
        - c Mode S: A platform for a variety of other applications, such as Traffic Information Service (TIS), Graphic Weather Service, and Automatic Dependent Surveillance-Broadcast (ADS-B). It provides improved surveillance quality, discrete aircraft addressing function and digital capability

B. VFR Transponder Operation
- i. Unless otherwise instructed by an ATC facility, squawk 1200 when operating VFR
    - a. Flight following is the most common example as to when you would squawk something other than 1200 (more info below in part 5. Radar Assistance)
- ii. If equipped, Mode C should be activated
    - a. Unless ATC requests otherwise or the equipment has not been tested as required in FAR 91.217

C. Mode C Transponder Requirements
- i. A mode C transponder is required:
    - a. At or above 10,000’ MSL over the contiguous 48 states (and DC), excluding the airspace below 2,500’ AGL
    - b. Within 30 nm of a Class B airspace primary airport, below 10,000’ MSL
    - c. Within and above all Class C airspace, up to 10,000’ MSL
    - d. Within 10 nm of certain designated airports, excluding airspace outside Class D and below 1,200’ AGL

D. Emergency Transponder Codes
- i. 7500 – Hijack
- ii. 7600 – Lost Communications
- iii. 7700 – Emergency
- iv. When making a code change, avoid inadvertently selecting 7500, 7600, or 7700 to avoid causing momentary false alarms at ground facilities

E. Transponder Related Terms
- i. These can be found in the AIM, Chapter 4-1-20 Part h

5. Lost Communication Procedures (AIM 4-2-13)

A. Arriving Aircraft
- i. Receiver Inoperative
    - a. Class D
        - Remain outside or above the Class D area until the direction and flow of traffic has been determined, then advise tower of your type of aircraft, position, altitude, intention to land and request light gun signals
        - Approximately 3-5 nm from the airport advise the tower of your position and join the pattern
            - a From this point on watch the tower for light gun signals, and transmit your position on the downwind leg and/or turning base
- ii. Transmitter Inoperative

        a. Remain outside or above the Class D area until the direction and flow of traffic has been determined, then join the traffic pattern, and monitor the local control frequency and look for a light gun signal
            - During daylight hours acknowledge light gun signals by rocking your wings
            - At night, blink you landing lights or navigation lights
    iii. Transmitter and Receiver Inoperative
        a. Remain outside or above the Class D area until the direction and flow of traffic has been determined, then join the traffic pattern and look for light gun signals from the tower
            - During daylight hours acknowledge light gun signals by rocking your wings
            - At night, blink you landing lights or navigation lights

B. Departing Aircraft
    i. Make every effort to have the equipment repaired
    ii. If unable to have the equipment repaired, call the tower by phone and request authorization to depart without radio communication
        a. If authorized, tower will give departure information and requested to monitor the tower frequency and/or look for light gun signals
            - During daylight, acknowledge instructions by moving the ailerons or rudder
            - At night, blink the landing or navigation lights
    iii. If your radios fail after leaving the parking area, watch the tower frequency for light signals, and continue to monitor tower (if you can receive transmissions)

6. **Equipment Issues that could cause loss of Communication**
    A. Radio Failure
        i. In the Aircraft
            a. Attempt to troubleshoot the situation with the applicable checklist(s)
            b. Transmitting
                - If you can't transmit, but can hear relay that information to the controller
                    a This can be done by ident-ing when asked if you can hear their radio calls, or if in sight of a tower the pilot can rock the wings or flash the lights
            c. Receiving
                - If you can transmit but cannot receive, inform ATC of the situation and transmit your intentions as you continue to the airfield
            d. Both
                - Follow the lost communications procedures
        ii. On the Ground (ATC radio failure)
            a. Transmitting
                - If ATC cannot transmit, you will not know if they can receive. Continue to make radio calls and assume their radios have failed
                - Transmit over guard (121.5) as well
            b. Receiving
                - If ATC can transmit, they can inform you of the problem, but cannot hear you. Follow their instructions
            c. Both
                - If there is a total failure, follow the lost communications procedures
                - Communicate with other aircraft on the same frequency and use guard if needed (121.5)

7. **Radar Assistance** (AIM 4-13-1)
    A. Radar equipped FAA ATC facilities provide radar assistance and navigation service to VFR aircraft provided they can communicate and are in radar coverage and are radar identified

B. Navigational guidance issued is advisory and the job of flying the aircraft safely remains with the pilot
    i. Keep controllers advised if their instructions will take you into IMC
C. Controllers have complete discretion for determining if they can provide the service. Factors that can prevent radar assistance:
    i. Radar limitations
    ii. Volume of traffic
    iii. Communications frequency congestion
    iv. Controller workload

8. NTSB Accident/Incident Reporting

A. Federal regulations require operators to notify the NTSB immediately of aviation accidents and certain incidents
    i. An accident is defined as an occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage
    ii. An incident is an occurrence other than an accident that affects or could affect the safety of operations
    iii. Report an Aircraft Accident to the NTSB

9. Runway Status Lighting Systems

A. Overview
    i. Fully automatic advisory system combining airport lighting equipment with airport surveillance systems; designed to reduce runway incursions at major US airports
    ii. Tells pilots and vehicle operators when runways are not safe through red lights embedded in the pavement
        a. Red in-pavement lights illuminate when it's not safe to enter, cross, or begin takeoff on a runway
        b. Only indicate runway status, but do not indicate clearance to enter/cross a runway
B. Runway Entrance Lights
    i. Illuminate when an aircraft is landing or taking off and indicate it is not safe to enter the runway environment
    ii. Pilots/vehicles must stop at the Runway Hold Line and remain stopped when the runway entrance lights are on
C. Takeoff Hold Lights
    i. Illuminate when an aircraft is in position on a runway takeoff hold area and an aircraft or vehicle is on the runway somewhere in front of it

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Poor Communication

A. Radio communications are a critical link in the ATC system. The link can be a strong bond between pilot and controller or it can be broken with surprising speed and disastrous results, thus poor communication should be avoided. (AIM 4-2-1)
    i. The single, most important thought in pilot-controller communication is understanding
        a. Acknowledge each radio communication with the appropriate call sign

        - Brevity is important, and contacts should be kept as brief as possible, while ensuring the controller knows what you want. Since concise phraseology may not always be adequate, use whatever words are necessary to get your message across

B. 4 Elements are required for communication to take place
   i. The sender
      a. Who or what is sending the message (could be ATC communicating a clearance, a system in the cabin communicating information about the aircraft, or the pilot communicating a control input to the aircraft)
   ii. The message
      a. What is being communicated (i.e., the clearance by ATC, a complaint by one of your passengers, or an indication from one of your gauges)
   iii. The medium
      a. How the message is sent (auditory, visual, over a radio, data uplink, or in person)
   iv. The Receiver
      a. Who receives the message, although who receives the message is not always who the message is intended for: aircraft with similar N-numbers, for example.
   v. Considering the complexity involved in communication, as pilots it is imperative that clear concise communication be consistently exercised

C. Radio Technique
   i. Listen before you transmit
   ii. Think before keying your transmitter
      a. Know what you want to say, and if it’s lengthy, jot it down
      b. Be alert to the sounds or lack of sounds in your receiver
         - Check your volume, the frequency, radio settings, and make sure that your microphone is not stuck in the transmit position

2. Failure to Recognize and Declare an Emergency

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."

B. What actually constitutes an emergency can vary based on the situation
   i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination

C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
   i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.

D. Hesitation/Fear of Declaring
   i. For whatever reason, there is often a hesitation to declare an emergency
      a. In some circumstances, pilots can feel that by declaring an emergency means they failed
   ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
      a. If you are experiencing an emergency, declare an emergency – don’t wait, don’t hesitate
         - Err on the side of caution
   iii. No one knows you have an emergency until you tell them
      a. ATC can’t do anything to help you if they don’t know there’s a problem
      b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
         - It gives you additional help

E. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
    i. Do not risk lives because you don't want to declare an emergency
        a. Your pride has no place in a real or potential emergency situation
    ii. Do not ever declare an emergency simply for priority

F. AvWeb: Declaring an Emergency and what happens next

3. Confirmation or Expectation Bias

A. As mentioned above, understanding is the most important aspect of communication. Therefore, it's very important to listen to the instructions given by ATC
    i. It's very easy to hear what you expect ATC to say
        a. For example: You're at your home airport, you've always received the same taxi instructions to runway 27. Rather than listening to the instructions ATC gives you, out of habit you read back what you're used to hearing. This can cause safety issues if there's another aircraft on your normal route, construction, or a taxiway closure.

B. Always listen to and read back the instructions ATC gives you, not what you expected to hear
    i. Clarify the instructions with ATC if you're ever unsure

SKILLS

The applicant demonstrates the ability to:

1. Select appropriate frequencies.
2. Transmit using phraseology and procedures as specified in the AIM.
3. Acknowledge radio communications and comply with instructions.

III.B. Traffic Patterns

References: 14 CFR part 91, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Towered and Non-Towered Airport Operations

A. Overview

i. Controlled - The pilot receives a clearance to approach/depart and pertinent pattern information. The pattern information will dictate which runways are in use.

  a. Although the runway information is dictated, you may ask to use another runway

ii. Uncontrolled - It's up to the pilot to determine traffic direction, and comply with the appropriate rules

  a. Unless safety dictates otherwise, land on the runway with the greatest headwind

  - If you must land on a runway that is not favored by the wind do not exceed any limitations (crosswind, tailwind, landing distance, etc.)

iii. If familiar with the basic rectangular pattern, approaches/departures will be easy at most airports

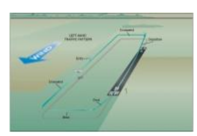
iv. Standard Traffic Pattern

  a. The Basics

  - Pattern Altitude: Usually 1,000' AGL
    - a A common altitude is the key factor in minimizing collisions at uncontrolled airports
    - b The chart supplement will usually specify nonstandard pattern altitudes
  - Standard Traffic Patterns: Left Turns
    - a All turns are left unless otherwise noted (Chart Supplement, Tower Controller, Airport Markings, etc.)
    - b Turns should not be banked more than 30°
      1. Use rudder to maintain coordination; do not use rudder to increase the rate of turn, this could result in a cross controlled stall

  b. Pattern Legs

  - Upwind Leg - The departure leg, flown parallel and in the same direction as runway heading
  - Crosswind Leg – The transition from the upwind leg to the downwind leg
    - a Perpendicular to the upwind leg (90° turn)
    - b Fly the crosswind leg to provide approximately ½ to 1-mile separation from the runway
  - Downwind Leg - Parallel to the runway of intended landing
    - a The heading flown is opposite the landing runway
      1. EX: Landing runway 10, downwind heading is 280° (no wind)



    - b Approximately ½ to 1 mile from the runway
    - c Before landing checks, and configuration (flaps, gear) are normally accomplished downwind
    - d Descent is normally started on the downwind leg, abeam the point of intended touchdown
    - e The downwind leg normally continues to a point 45° off the intended landing point, past the departure end of the runway
      1. The turn to the base leg is started at the end of the downwind leg
      2. This point can be adjusted as necessary based on circumstances

        a. Winds, other traffic, emergency situation, etc. can require adjustments
    c. Base Leg - Perpendicular to the runway and the transition between downwind and final
        - The ground track of the airplane should be perpendicular to the extended centerline
            - a Heading is 90º off the runway direction (with no wind)
        - Continue the descent adjusting pitch and power as necessary to maintain airspeed, glideslope, and aim point
        - Begin the turn to final in order to end up established on the extended centerline of the runway
    d. Final - The final descent of the approach, aligned with the landing runway
        - Adjust the turn from base in order to center the aircraft on the runway
        - Crab into the wind in order to maintain ground track
        - Adjust pitch and power as necessary to maintain airspeed, glideslope, and aim point

v. 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 45º turn to the left (or right, for a right pattern)

vi. Maintaining the Desired Ground Track (on any leg in the pattern)
    a. The goal is to fly a rectangular pattern regardless of the wind direction or speed
        - The airplane will have to be crabbed into the wind in order to maintain a straight ground track
        - Maintain awareness of the wind direction in relation to the aircraft, adjust heading as necessary to maintain ground track
    b. Visual references are very helpful in maintaining ground track
        - Upwind: Glance behind briefly to ensure you are maintaining the runway centerline
        - Crosswind: Use the runway as a reference; note and correct for any drift to or from the runway
        - Downwind: Place the runway at a point on the leading edge of the wing and adjust as needed
            - a EX: Place the runway 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)
        - Final: Maintain the centerline, crab as necessary to correct for the wind
        - Familiar Airports may have well known references for the pattern
            - a These are helpful for learning the pattern, but these references will not exist at other airports; be sure to teach references that can be carried from airport to airport
    c. A common error is poor altitude or airspeed control
        - Know the airspeed required at certain points in the pattern (max speed is 200 knots in Class D)
            - a Adjust as necessary, excessively fast or slow speeds can cause a hazard to other traffic
        - Constantly check the instruments to ensure airspeed and altitude are as desired; make fine, controlled adjustments when necessary
        - At slow speeds, close to the ground airspeed control is very important
            - a A stall within 1,000' AGL could be unrecoverable
    d. Another common error is improper corrections for wind drift
        - Keep the pattern a rectangle, crab into the wind as necessary
        - Use the heading bug or make a mental note of the wind direction from the ATIS/ASOS and adjust heading as necessary to correct for the wind

        - Use visual references

B. Controlled Field
    i. The pilot receives, by radio, a clearance to approach/depart as well as pertinent information about the pattern
    ii. ATC will specify pattern entry and departure procedures (Where/how to enter and depart)
    iii. During the pattern the controller may make adjustments (speed, legs lengths, turns for spacing, etc.)
    iv. A common error is a failure to comply with traffic pattern instructions, procedures, and rules
        a. Know the rules and ensure you understand radio communications and instructions
            - If you're unsure ask!
        b. Learn to divide attention in the pattern between flying, collision avoidance, checklists, and communications

C. Uncontrolled Field
    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, traffic, NOTAMs, etc.
                    1. They are not a controller, the FSS just provides information for your use
                b Inbound aircraft should initiate contact approximately 10 miles out with altitude, aircraft type, and location
                c Departing aircraft should transmit their 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 Announce your position and intentions on the CTAF frequency
                b 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 other aircraft are not in the pattern, use traffic indicators and wind direction to determine the runway in use
                a Look for L shaped indicators displayed with a segmented circle (the short part of the L shows the 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. Once pattern direction is determined, proceed to a point well clear of the pattern before descending
        c. Enter the pattern in level flight, at pattern altitude, at a 45° angle to the downwind leg, abeam the runway midpoint
            - Entry while descending creates collision hazards and should be avoided
                a Since you cannot see below the cowling, you could unknowingly descend onto another aircraft in the pattern; always enter at pattern altitude and clear aggressively
    iii. Departing
        a. Monitor the radio for other traffic in the local area
        b. Announce your intentions
        c. Clear aggressively prior to takeoff and on departure

- Radio communication is not required at an uncontrolled field

iv. A common error is a failure to comply with traffic pattern instructions, procedures, and rules
   a. Know the rules and ensure you understand radio communications
   b. Learn to divide attention in the pattern between flying, collision avoidance, checklists, and communication
   c. Clear aggressively, especially at uncontrolled airfields
   d. Follow the procedures established and in use at uncontrolled fields

D. Orientation to the Runway
   i. Know which runway is in use and remain oriented with the runway
      a. Plan to enter properly visualizing your position in relation to the runway on the heading indicator
      b. Confirm the runway number with the heading indicator during all pattern legs
         - Downwind – reciprocal of the landing runway; Base - 90^{o} off (in the direction of the pattern); Final – Same as the runway number

2. Runway Selection for the Current Conditions

A. General
   i. Runway selection can vary based on a number of factors. Usually, the pilot will choose the runway with the highest headwind component for takeoff and landing.
      a. Since winds are reported from the direction they are coming from, the runway that most closely matches the reported wind has the highest head wind
         - For example, wind reported 050 at 10 knots is coming from the north east. Since the pilot prefers to take off into the wind to obtain the greatest headwind component, runway 05, or whatever runway is closest to 050 will provide the highest headwind component.
      b. Other factors to consider are safety, the runway length and width, other traffic, airfield procedures, departure direction, etc.
         - Always choose the safest option. In some cases, it would be safer to use a runway with a higher crosswind if it's longer and wider, or if it avoids other traffic that could be a hazard
         - The higher the headwind, the better the aircraft performance (shorter the ground roll for both takeoff and landing)
   ii. Always ensure the runway you select falls within the limitations of the aircraft
      a. Things to consider include takeoff and landing distance
   iii. What are the current winds?
      a. The current wind conditions can be found in various ways:
         - At a towered airport, the most common source of information is ATIS (or other weather reporting system)
         - At airports without weather reporting, wind indicators can provide the information you're looking for
            a Wind Cone, Wind Sock, or Wind Tee installed near the operational runway to indicate wind direction
            b The large end of the wind cone, wind sock, and wind tee (the cross bar) points INTO the wind
            c The wind indicator may be located in the center of the segmented circle (indicating traffic pattern direction) and may be lighted for night use
            d Pilot are cautioned against using a tetrahedron to indicate wind direction
               1. The tetrahedron is used strictly for landing direction (the small end points in the direction of landing)

        2. Use extreme caution when making runway selection by use of a tetrahedron in very light or calm wind conditions as it may not be aligned with the designated calm wind runway

B. Towered
   i. The pilot will likely be directed to the runway in use
      a. You do have the option of asking for a different runway, and assuming it's safe, the tower will likely oblige (traffic permitting)
      b. In the case that multiple runways are in use, be ready to advise tower which runway you would prefer
C. Non-Towered
   i. Arriving
      a. As mentioned above, listen to the CTAF frequency, observe other traffic in the pattern and conform to the traffic pattern in use
         - Common practice is to overfly the airfield (safely above the traffic pattern altitude) to observe the traffic, and wind indicators
      b. If other aircraft are not in the pattern, use traffic indicators and wind direction to determine the runway in use
   ii. Departing
      a. Use the weather reporting information, or if there is none, the wind indicators to choose the safest runway
         - Stay within all limitations

3. Right-of-Way Rules (FAR 91.113)

A. An aircraft in distress has the right-of-way over all other traffic
B. Converging Aircraft
   i. When aircraft of the same category are converging at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
   ii. If they are different categories:
      a. A balloon has the right of way over any other category
      b. A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
      c. An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
      d. However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
C. Approaching Head-on
   i. Each pilot shall alter course to the right
D. Overtaking
   i. The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
E. Landing
   i. Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
      a. Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   ii. When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
      a. Don't take advantage of this rule to cut in front of another aircraft

4. Use of Automated Weather and Airport Information

A. ASOS, AWOS, and ATIS
    i. ASOS (Automated Surface Observing System)
        a. Continuous minute-by-minute observations to generate a METAR and can provide other information
        b. ASOS software transmits a SPECI report whenever it determines a significant change in conditions
        c. Types of Observations
            - Every ASOS contains:
                a Cloud height indicator
                b Visibility Sensor
                c Precipitation identification sensor
                d Freezing rain sensor (at select sites)
                e Pressure sensors
                f Ambient temperature and dew point temp sensors
                g Anemometer (wind direction & speed)
                h Rainfall accumulation sensor
            - Some include precipitation discriminator which differentiates liquid/frozen precipitation
                a If it has this capability, it's designated as A02 in the remarks section (otherwise A01)
            - At selected ASOS installations lightning detection equipment is installed
        d. Limitations
            - ASOS cannot distinguish between stratus and cumulonimbus clouds
            - It is limited in its ability to identify restrictions to visibility
                a No prevailing, sector, tower visibility (Input from a trained human observer is integral part)
        e. Levels of service
            - LEVEL A - The highest – which is typically available at major airports like those in or near Class B
                a Other levels offer less human augmentation, with fewer types of weather reported
            - LEVEL B – Has human observers available 24 hours a day
            - LEVEL C – At airports with part-time towers (Human augmentation ends when tower closes)
            - LEVEL D – Found at smaller, nontowered airports meeting the FAA or NWS criteria for the ASOS
                a Unattended, and always contain the AUTO designation when in a METAR
    ii. AWOS (Automated Weather Observing System)
        a. First widely installed automated weather data gathering system at US airports
        b. AWOS is available in lesser configurations without all the types of observations listed above
        c. Levels of service:
            - AWOS-A: Only reports the altimeter setting
            - AWOS-1: Also measures and reports wind speed, direction, gusts, temperature, and dew point
            - AWOS-2: Adds visibility information
            - AWOS-3: Most capable system – also includes cloud/ceiling data (essentially equivalent to ASOS)
                a Like ASOS, AWOS-3 can include precipitation discrimination sensors indicated by A02
                b Lightning detection is also a possible enhancement for selected AWOS-3 sites
        d. Difference between ASOS/AWOS is ability to identify/report significant changes in surface weather

- AWOS transmits 3 reports per hour at fixed intervals and cannot issue a special report as needed

iii. ATIS (Automatic Terminal Information Service)
  a. A continuous broadcast of recorded non-control information in busier terminal areas
  b. Contain essential info - weather, active runways, approaches, and other required info (NOTAMs)
  c. Updated when there is a significant change in the information; it is given a letter designation
  d. In its simplest form, the ATIS is a continuously playing recording of a person reading the message
  e. Re-recorded at every update, which is quite cumbersome
  f. Data may be entered by hand, coming from a METAR, or be taken directly from sensors
    - Modern systems are fully automated and do not require a controller except in case of sensor failures/unusual activities
  g. Some airports have a separate ATIS for arriving/departing aircraft, each on its own frequency

B. Use of Automated Weather and Airport Information
  i. Automated weather sources such as the AWOS, ASOS, and ATIS provide current airport weather information (usually within the last hour)
    a. These provide local weather conditions and other relevant information for a specific airport
      - Although they are for a small area, when combined with other airports around the area the pilot can build a bigger picture of the local weather
  ii. The weather and airport information are extremely helpful to both arriving and departing aircraft
    a. Always make a point to obtain the latest weather prior to arrival/departure
    b. This information paints a picture of the conditions at the airfield
      - The pilot knows what runway to expect based on the airport information (or, if a specific runway isn't mentioned, the wind conditions can provide a good idea as to what to expect)
      - Cloud cover, temp/dew point, altimeter settings, etc. can be obtained as well as any other important information the tower may choose to include (NOTAMs, changes to normal procedures, etc.)
  iii. Additional Airport Information in the Chart Supplement
    a. The Chart supplement provides the most comprehensive information on a given airport
      - It includes everything from runways, runway material, runway slope, frequencies, hours of operation, phone numbers, and lots more

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Collision Hazards to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
  i. Operation Lights On
    a. A voluntary FAA safety program to enhance the see and avoid concept
    b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
  ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
  a A balloon has the right of way over any other category
  b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
  c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
  d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
   - Each pilot shall alter course to the right

d. Overtaking
   - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
   - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
     a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
     a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
   - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
   - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. Before Takeoff: Scan the runway and final approach for other traffic

b. Climbs and Descents: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   - This is more applicable to climbs to your cruising altitude but may be necessary to find other traffic when climbing or descending in the pattern

c. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
   - This is also more applicable to cruise, but can be used while level in the pattern if necessary

d. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field

        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
      b. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      c. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span approaches to runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing
   iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
      a. Ensure proper clearance between the aircraft and obstacle
         - If unsure of clearance, stop until you're sure it is safe to pass
         - If necessary, radio ground to inform them of your intentions or ask for assistance

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. In the traffic pattern, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.
   ii. At a controlled field, listen to ATC's instructions
      a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
   iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)

iv. Fly first!
    a. Aviate, Navigate, Communicate
v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air
  i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
  ii. There is no place for distractions in the traffic pattern and in the runway environment
  iii. Maintain situational awareness
    a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

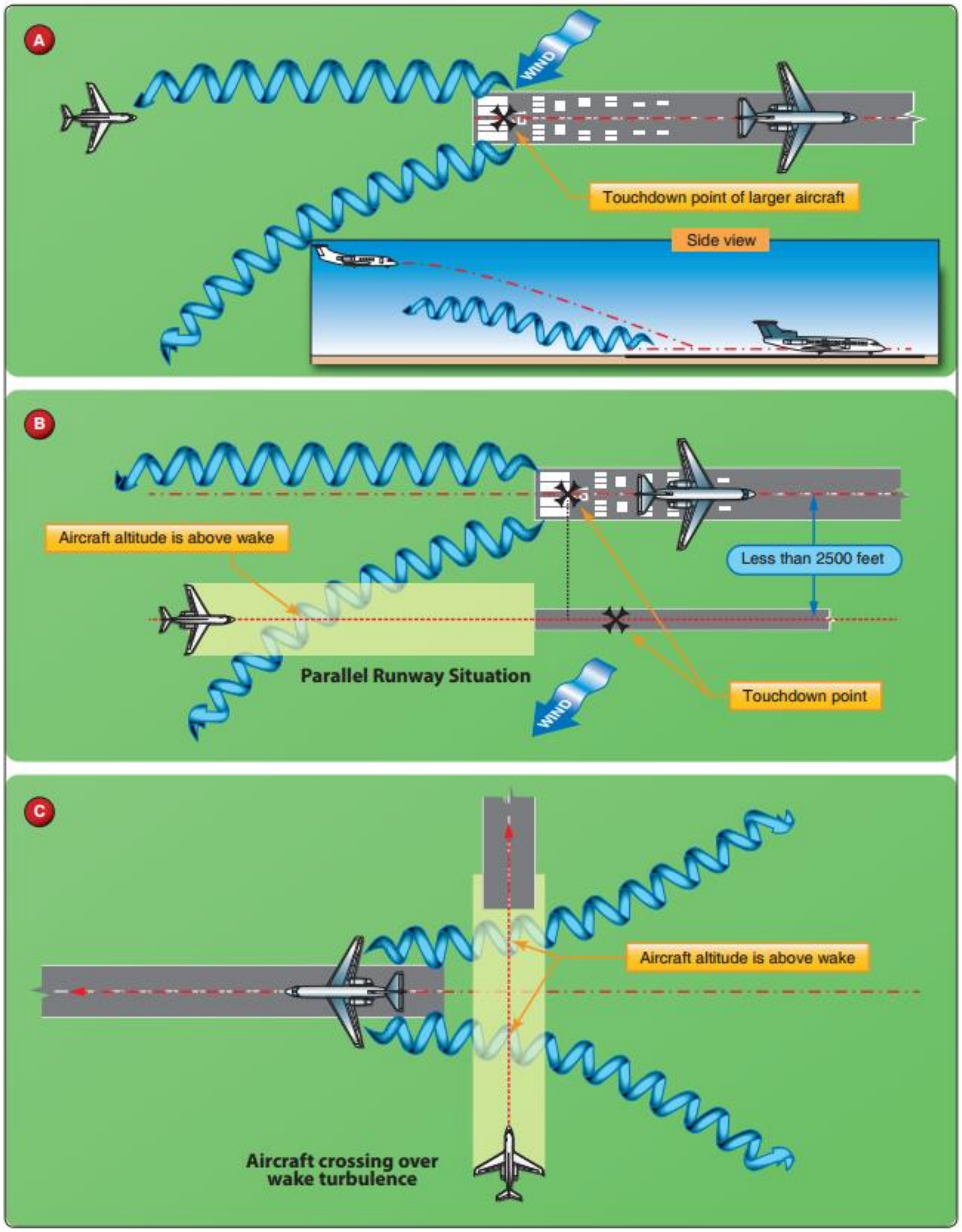
C. Task Management
  i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks
  iii. Recognize when you are getting behind the aircraft, and find a way to catch up
    a. If more time is needed, go around, find somewhere to hold/circle, or slow down
    b. Ask for assistance, if possible
    c. Don't give up or overstress yourself. Take it one step at a time.

3. Wake Turbulence and/or Windshear

A. Wake Turbulence
  i. All aircraft generate wake turbulence during flight.
    a. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
    b. The vortices from larger aircraft pose problems to aircraft encountering them
      - The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft
  ii. Wake Turbulence Recognition in the Terminal Area
    a. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
    b. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
      - The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft
  iii. Wake Turbulence Resolution
    a. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
      - Parallel runways – stay at and above the other jet's flight path for the possibility of drift

- Crossing runways – cross above the larger jet's flight path

iv. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



B. Windshear
   i. What is it?
      a. Unexpected change in wind direction and/or wind speed
      b. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft
   ii. Where is it?

a. It is often associated with thunderstorms
    - Microbursts
        a These can be extremely dangerous

b. Inversion layer
    - Sometimes an inversion layer will result in a wind shift during descent

iii. Dealing with it

a. Avoid It!
    - DO NOT FLY if there is potential for wind shear
    - Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
    - LLWAS (Low Level Wind Shear Alerting System)
        a Most major airports have an LLWAS
        b If available, it can warn of impending wind shear
        c PIREPS can be very informational
            1. Direct reports from other pilots who experienced the wind shear

b. Approach into Wind Shear
    - If an option, divert to an airport with favorable weather conditions, otherwise,
        a Use more power
        b Maintain a Faster approach airspeed
            1. Add ½ the gust factor to the approach speed
        c Stay as high as feasible until necessary to descend
        d Go Around at the first sign of a change in airspeed or unexpected pitch change

c. Important to get FULL power and get the aircraft into a max performance climb

SKILLS

The applicant demonstrates the ability to:

1. Properly identify and interpret airport/seaplane base runways, taxiways, markings, signs, and lighting.
2. Comply with recommended traffic pattern procedures.
3. Correct for wind drift to maintain the proper ground track.
4. Maintain orientation with the runway/landing area in use.
5. Maintain traffic pattern altitude, ±100 feet, and the appropriate airspeed, ±10 knots.
6. Maintain situational awareness and proper spacing from other aircraft in the traffic pattern.

TAKEOFFS, LANDINGS & GO AROUNDS

IV.A. Normal Takeoff and Climb

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Effects of Atmospheric Conditions, Including Wind, on Takeoff and Climb Performance**
   - A. Atmospheric conditions greatly affect takeoff distance
     - i. Pressure Altitude
       - a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
         - $1{,}000(29.92 - \text{Alt}) + \text{Elev}$
       - b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
         - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
           - a Therefore, aircraft takeoff and climb performance will improve with higher air pressure (shorter takeoff distance, and increased climb performance)
         - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather
     - ii. Density Altitude/Temperature
       - a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
         - $120(°C - 15°C) + PA$ (this is an approximation)
       - b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
         - Lower temperatures (the air is more compressed) result in better performance
         - Higher temperatures (the air is less compressed) result in poorer performance
         - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
           - a Lower temperatures result in better performance (shorter takeoff run and increased climb performance)
           - b Overall, high pressure, cold days result in the best takeoff and climb performance
     - iii. Humidity
       - a. Although not directly accounted for on the performance charts, humidity decreases performance
   - B. Wind Conditions and Effects
     - i. Wind and Takeoff Distance
       - a. The effect of wind on takeoff distance is large, and proper consideration must be given when predicting takeoff distance
       - b. A headwind allows the aircraft to reach lift-off speed at a lower groundspeed
         - There is wind moving over the wings while the aircraft is standing still, thus the aircraft can leave the ground at a lower ground speed
       - c. A tailwind requires the aircraft reach a higher groundspeed to reach lift off speed
         - If there is a 10-knot tailwind, the aircraft has to accelerate to 10 knots before the speed of the air over the wings reaches 0 knots
     - ii. Headwinds also increase the aircraft's ability to climb

a. Greater airflow over the wings results in increased lift and therefore increased climb performance
b. A headwind also decreases the aircraft's groundspeed allowing the aircraft to climb to a given altitude in a shorter distance

2. V_X and V_Y

A. V_X: The speed at which the aircraft obtains the highest altitude in a given horizontal distance. The best Angle of Climb (AOC) speed normally increases slightly with altitude.
 i. An example of when max AOC is used, is when taking off from a short airfield surrounded by high obstacles (trees, power lines, etc.)
 ii. V_X occurs at the airspeed and angle of attack combination which allows for the maximum excess thrust

B. V_Y: The speed at which the aircraft obtains the maximum increase in altitude per unit of time. The best Rate of Climb speed normally decreases slightly with altitude.
 i. V_Y depends on excess power and occurs at the airspeed and angle of attack combination that produces the most excess power.
  a. Since climbing is work, and power is the rate of performing work, a pilot can increase the climb rate by using any power not used to maintain level flight

3. Appropriate Aircraft Configuration

A. Follow the manufacturer's instructions in the POH
B. The performance charts are based on the configuration as specified in the POH. Using a different configuration would negate the information from the charts

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

A. Pilot Capability
 i. Not only should a pilot have personal weather minimums, but also runway minimums
  a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
  b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
  c. These limitations may vary based on conditions (for example, whether the runway is wet or dry, etc.)

B. Aircraft Performance and Limitations and the Available Distance
 i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
  a. Do not attempt to takeoff or land from a runway that is not supported by the landing data
  b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe takeoff and climb
   - Take into account the runway distance available as well as potential obstacles on climb out
  c. Do not exceed any flight limitations – follow the flight manual

ii. The minimum takeoff distance is obtained by taking off at some minimum safe speed for the current conditions that allows sufficient margin above stall and provides satisfactory control and initial rate of climb
    a. Generally, the lift-off speed is some fixed percentage of the stall speed or minimum control speed

iii. Calculate Takeoff Distance based on the current atmospheric conditions using the manufacturer's takeoff distance tables for a Soft-Field Takeoff
    a. Using the local weather information (METAR, TAF, etc. depending on when you intend to takeoff) obtain takeoff distance with the performance charts in the flight manual
    b. The takeoff distance should be compared to the runway available

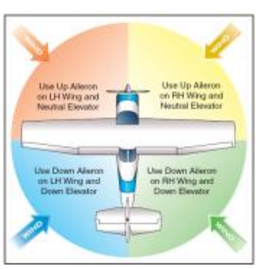
iv. Factors affecting Takeoff Distance
    a. Weight
        - Higher weights increase takeoff distance
    b. Wind
        - Increased Headwinds decrease takeoff distance
    c. Pressure/Density Altitude
        - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases takeoff distance
    d. Runway Slope and Condition
        - An inclined runway will increase takeoff distance
        - Different types of runways can affect the takeoff distance
            a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction to overcome on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual.

C. The most favorable runway for takeoff meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
    i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
        a. This runway may be more favorable because it is aligned with your departure direction, it may be a shorter taxi, it may be longer, or it may provide a safer climb
            - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

2. Crosswind

A. While usually preferable to takeoff directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind

B. Crosswinds and Taxiing
    i. Taxiing with a tailwind
        a. Usually will require less engine power after the initial ground roll is begun
        b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally
    ii. Taxiing with a quartering headwind



Ailerons are turned into the headwind and the elevator is held neutral

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

Also, the downwind aileron will be DOWN
- A small amount of lift/drag is put on this wing keeping the upwind wing down

iii. Taxiing with a Quartering Tailwind
    a. Ailerons are turned with the wind and the elevator is DOWN
        - Dive with the Wind
        - This reduces the tendency of the wind to nose the plane over
        - The upwind aileron is DOWN in this case (opposite of a head wind)

iv. These corrections minimize weathervaning and provide easier steering
v. Always know the direction of the wind in relation to the airplane
    a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Crosswinds and Takeoff
i. Taxi onto the Runway
    a. Before taxiing onto the runway adequately clear the area; do not taxi onto the runway if it is not safe
    b. The airplane should be carefully aligned with the intended takeoff direction, and the nose wheel positioned straight, or centered
ii. If a crosswind is indicated (windsock, ATIS, other direction indicators) full aileron should be held into the crosswind as the roll is started
    a. This raises the aileron on the upwind wing to impose a downward force on the wing counteracting the lifting force of the crosswind and preventing the wing from raising
    b. With the aileron into the wind, the rudder should be used to keep the takeoff path straight
        - Rudder in the direction opposite of the aileron input is required to keep the takeoff path straight
iii. Gaining Speed
    a. As the forward speed is increased, the crosswind becomes more of a relative headwind and the air moving faster over the flight controls causes them to be more effective, therefore full aileron pressure into the wind should gradually be reduced
        - Some aileron pressure will need to be maintained – It doesn't all go away
            a Don't be mechanical in the use of aileron control, rather sense the need for varying aileron control input through feel for the plane and visual indications
            b Don't use excessive aileron input in the latter stage of the takeoff roll, this can result in a steep bank into the wind at lift-off (putting the wing near the runway surface)
                1. Slowly reduce aileron pressure as the crosswind becomes more of a relative headwind and the control surfaces become more effective
iv. Avoid an early lift-off resulting in side-skipping
    a. If the correction is not held properly, a skipping action may result
        - Indicated by a series of very small bounces
    b. Side-skipping imposes severe side stresses on the landing gear and could result in structural failure
v. Lift-Off
    a. In a significant crosswind, hold the main gear on the ground longer to ensure a smooth but definite takeoff
        - Leave the ground with more positive control and prevent side loading on the landing gear
    b. It is important that sufficient aileron is held into the wind so that immediately after liftoff the aircraft is side slipping into the wind to counteract drift
        - 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
            a This is acceptable and preferred to side skipping

c. Once the plane leaves the ground drift correction needs to be maintained
   - Visually
     a The runway will begin to disappear as the nose pitches upward
     b Maintain the centerline as well as airplane pitch and bank with outside references and instrument indications
   - Instrument Indications
     a Pitch to maintain V_Y (or whatever speed required for the situation)
       1. Make small adjustments as necessary for airspeed

D. Maximum Demonstrated Crosswind Component
   i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft
      a. Prior to takeoff use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
         - If this exceeds the maximum demonstrated crosswind component, takeoff is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used
      b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?
   i. Unexpected change in wind direction and/or wind speed
   ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?
   i. It is often associated with thunderstorms
      a. Microbursts
         - These can be extremely dangerous
   ii. Inversion layer
      a. Sometimes an inversion layer will result in a wind shift during descent

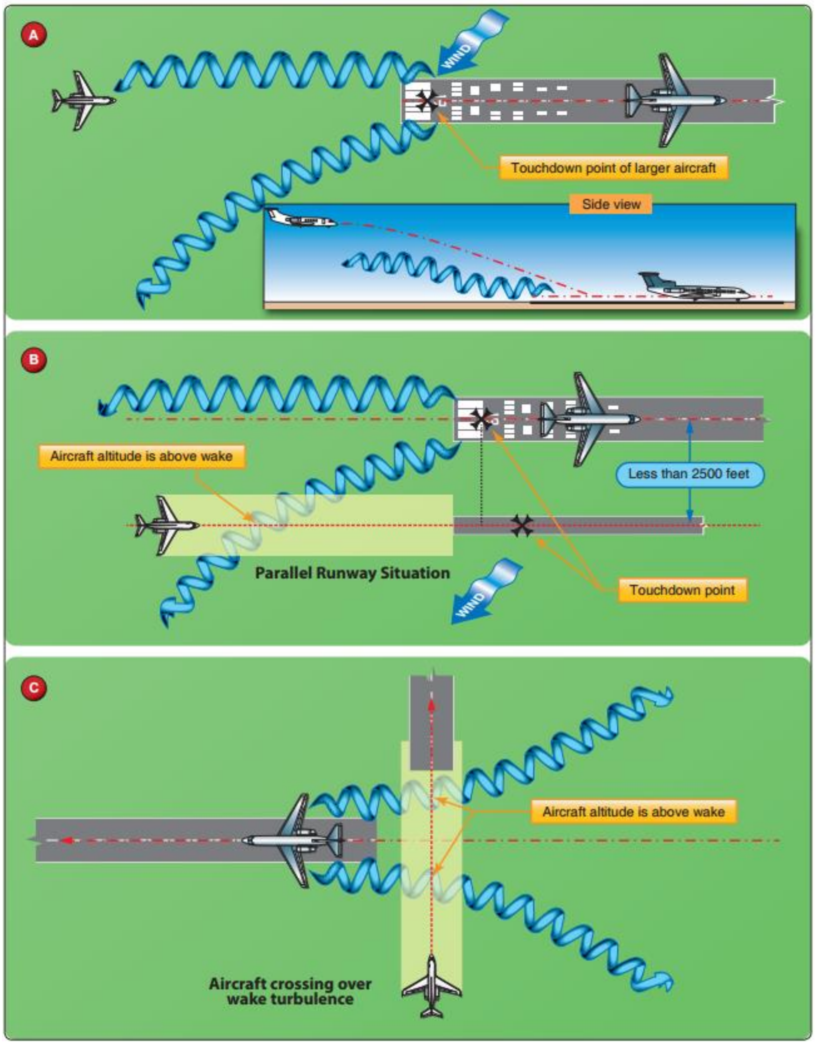
C. Dealing with it
   i. Avoid It!
      a. DO NOT FLY if there is potential for wind shear
      b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
      c. LLWAS (Low Level Wind Shear Alerting System)
         - Most major airports have an LLWAS
         - If available, it can warn of impending wind shear
         - PIREPS can be very informational
           a Direct reports from other pilots who experienced the wind shear
   ii. Wind Shear after Takeoff
      a. If possible, land straight ahead on the remaining runway
      b. If not, increase to max power, and begin a maximum performance climb
         - Be aware that the aircraft may not fly, you may be forced to land

4. Tailwind

A. A tailwind increases the runway required for takeoff
   i. Always verify the wind conditions and takeoff performance obtained are compatible with the runway of intended use

B. The flight manual will publish a maximum tailwind for takeoff, do not exceed this limit
C. Use the performance charts to verify takeoff performance with the projected winds

5. **Wake Turbulence**
   A. All aircraft generate wake turbulence during flight.
      i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
      ii. The vortices from larger aircraft pose problems to aircraft encountering them
         a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft
   B. Wake Turbulence Recognition in the Terminal Area
      i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
      ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
         a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft
   C. Wake Turbulence Resolution
      i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
         a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
         b. Crossing runways – cross above the larger jet's flight path
      ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. **Runway Surface/Condition**
   A. Runway conditions affect takeoff performance
      i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces
   B. Surface
      i. Runway surfaces vary widely. The runway surface may be concrete, asphalt, gravel, dirt, or grass
         a. The runway surface for a particular airport can be found in the Chart Supplement
         b. Any surface that is not hard (grass, dirt, etc.) increases the ground roll during takeoff
            - Tires can sink into soft runways and the tires do not roll smoothly over the surface
      ii. Braking effectiveness is another consideration when dealing with different runway types
         a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft
      iii. The gradient of the runway can also have an effect on the takeoff ground roll
         a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3’ for every 100’ of runway length

b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
c. An upsloping runway impedes acceleration and increases the takeoff roll

C. Condition
   i. Obstructions such as mud, snow, or standing water also reduce the aircraft's acceleration down the runway
      a. Dry runways provide the best acceleration
   ii. Braking effectiveness also comes into play for different runway conditions
      a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to reject a takeoff
         - Water decreases the friction between the tires and the ground, reducing braking effectiveness
         - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway's surface – braking and directional control are almost nil.
            a Grooved runways help to reduce hydroplaning
            b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
         - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
            a Use aerodynamic braking to its fullest advantage

D. Length
   i. Runway length obviously needs to accommodate the takeoff distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
   ii. Never attempt a takeoff on a runway that is not supported by the takeoff data
   iii. Ensure that runways are adequate in length for takeoff acceleration and deceleration when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for Rejected Takeoff and Engine Failure in Takeoff/Climb Phase of Flight

A. Always have a plan before starting the takeoff roll. Brief that plan
   i. The Air Force and airlines will brief every departure. The brief reviews the standard procedures, expected procedures and actions, as well as intentions in the case of an emergency during takeoff
      a. Prior to rotate speed, plan to keep the aircraft on the ground (assuming the runway distance allows this)
      b. From rotation to a certain point (runway distance allowing) you may be able to attempt to land on the remaining in the case of an engine failure. After this point, it will be unfeasible to land on the runway.
         - Use the distance remaining signs along the runway edges to know when it is too late to return
      c. Brief an altitude at and above which, you will turn around to return to the airport for landing
      d. Between the point at which you can no longer land on the remaining runway (a) and the point at which you have the altitude to return to the airport (b) you will have to land on the most suitable surface outside of the airport

B. Rejected Takeoff
   i. Circumstances such as engine malfunctions, inadequate acceleration, runways incursion, ATC conflict, or any other emergency can result in a takeoff having to be rejected on the runway
      a. Inadequate Acceleration

- Prior to takeoff, the pilot should have in mind a point along the runway at which the airplane should be airborne. If that point is reached and the airplane is not airborne, immediate action should be taken to reject the takeoff

b. Rejected Takeoff Procedures
   - Follow the procedures as specified the manufacturer's flight manual
   - Generally, the pilot will reduce power to idle, and apply maximum braking while maintaining directional control
     a If it is required to shut down the engine due to a fire, or for any other reason, the mixture control should be brought to the idle cutoff position and the magnetos turned off. Follow the manufacturer's emergency checklist

C. Engine Failure
   i. Time is of the essence
      a. In most instances the pilot only has a few seconds after engine failure to decide what course of action to take and to execute those actions
      b. Unless prepared in advance to make the proper decision, there is an excellent chance that the pilot will make a poor decision or no decision at all
   ii. Procedures
      a. The first responsibility is to maintain aircraft control
      b. During the takeoff roll, reject the takeoff and stop straight ahead
      c. Immediately following takeoff, if there is sufficient runway available straight ahead, land on the remaining runway
         - Ensure you know how much runway you need (descent + landing distance)
      d. During the takeoff climb
         - During the takeoff climb, the aircraft will have full power, a high pitch attitude and right rudder
         - When the engine fails, the pilot must immediately lower the nose (to the best glide speed) to prevent a stall and/or spin, and release the right rudder since the turning tendencies have been removed
           a If the engine doesn't totally fail, some right rudder may be necessary to maintain coordination
         - Once the pilot has control of the aircraft, establish a controlled glide toward a plausible landing area (preferably straight ahead on the remaining runway)

8. Collision Hazards

A. Collision Avoidance
   i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
   ii. 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 at approximately the same altitude (except head on), the aircraft to the others right has the right-of-way.
         - If they are different categories:
           a A balloon has the right of way over any other category

        - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    - c. Approaching Head-on
        - Each pilot shall alter course to the right
    - d. Overtaking
        - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    - e. Landing
        - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
            - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
        - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
            - a Don't take advantage of this rule to cut in front of another aircraft
- iii. Minimum Safe Altitudes (FAR 91.119)
    - a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
        - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
        - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure
- iv. Clearing Procedures
    - a. Before Takeoff: Scan the runway and final approach for other traffic
    - b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
- v. Scanning
    - a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

- i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    - a. Study sectionals and terminal area charts
    - b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    - c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
      - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
   b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb after takeoff
      b. Become familiar with any obstacles on the departure path
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing
   iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
      a. Ensure proper clearance between the aircraft and obstacle
         - If unsure of clearance, stop until you're sure it is safe to pass
   v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.
   i. Be alert for anyone/anything that may cause a hazard
      a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
         - Be cautious
         - Reject the takeoff or delay takeoff, if required
      b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
         - It may be necessary to reject a takeoff in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering

A. Low Altitude Maneuvering
   i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely

        - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
    - ii. Be aware of, and avoid obstructions on and around the airfield
        - a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
        - b. Plan ahead to avoid obstacles
- B. Low Altitude Stall/Spin
    - i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
        - a. Airspeed
            - Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
            - If you get any indication of a stall at low level, recover from the stall and climb to a safe altitude
                - a Max, Relax, Roll is a common memory aid for stall recovery
                    1. Apply max power
                    2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
                    3. And roll wings level
    - ii. Spin
        - a. A spin is a result of a stall + yaw
            - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
        - b. Prevention
            - Maintain coordination
            - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
            - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
        - d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual
- C. 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. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
        - b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    - iii. Recommendations:
        - a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
        - b. Know and fly above minimum published safe altitudes.
            - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
  i. In the traffic pattern and during the climb to altitude, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and transitioning to the en route structure
  ii. At a controlled field, listen to ATC's instructions
    a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
  iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
  iv. Fly first!
    a. Aviate, Navigate, Communicate
  v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
  vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in and around the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground or in the air
  i. Be aware of other traffic. Build a picture of what you see, and what you hear on the radio
  ii. Maintain situational awareness
    a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
  i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks

iii. Recognize when you are getting behind the aircraft, 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
        a Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Verify assigned/correct runway.
4. Ascertain wind direction with or without visible wind direction indicators.
5. Position the flight controls for the existing wind conditions.
6. Clear the area; taxi into takeoff position and align the airplane on the runway centerline.
7. Confirm takeoff power and proper engine and flight instrument indications prior to rotation.
8. Rotate and lift off at the recommended airspeed and accelerate to V_Y.
9. Establish pitch attitude to maintain the manufacturer's recommended speed, or V_Y +10/-5 knots.
10. Configure the airplane in accordance with manufacturer's guidance.
11. Maintain V_Y +10/-5 knots to a safe maneuvering altitude
12. Maintain directional control and proper wind drift correction throughout takeoff and climb.
13. Comply with noise abatement procedures.

IV.B. Normal Approach and Landing

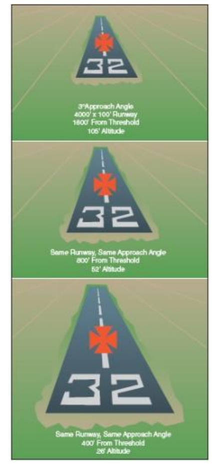
References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

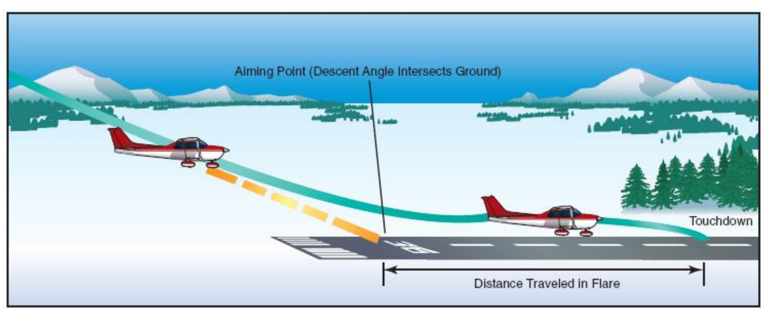
The applicant demonstrates understanding of:

1. **Available Landing Distance**
   - A. Calculate landing distance based on the current atmospheric conditions using the manufacturer's landing distance tables
     - i. Using METAR and TAF information (depending on when you intend to land) obtain landing distance with the landing distance charts in the flight manual
     - ii. The landing distance should be compared to the runway available
     - iii. Landing Distance will vary based on factors such as weight, density altitude, runway surface and gradient, wind conditions, etc.
   - B. Factors affecting Landing Distance
     - i. Weight
       - a. Higher weights increase landing distance
     - ii. Wind
       - a. Increased Headwinds decrease landing distance
     - iii. Pressure/Density Altitude
       - a. A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases landing distance
     - iv. Runway Slope and Condition
       - a. An inclined runway will decrease landing distance
       - b. Different types of runways can affect the landing distance
         - For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual
2. **A Stabilized Approach to Include Energy Management Concepts**
   - A. A Stabilized Approach
     - 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.
       - a. A stabilized approach is a safe approach
       - b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
       - c. Adjust Pitch for airspeed and Power for altitude to maintain speed and glidepath
     - ii. Controlling Descent
       - a. Adjust power and pitch as necessary to maintain a stabilized approach and glide slope
         - Region of Reverse Command
           - a Below LD_{MAX}
           - b Use pitch for airspeed and power for altitude
             1. Pitching up decreases airspeed and vice versa
             2. Increasing power decreases your rate of descent and vice versa
           - c Trim the control forces to maintain airspeed
       - b. A change in any of the variables requires a coordinated change in the other controllable variables
         - EX: Why do we never try to stretch the gliding distance with back pressure alone?

a. If the Pitch attitude is raised too high without increasing power this will cause the airplane to settle rapidly, short of the desired landing spot
    1. The gliding distance is shortened if power is not increased simultaneously
- Proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
    a. If the approach is too high, lower the nose and reduce power
    b. If the approach is too low, add power and raise the nose
    c. Stay on airspeed



iii. The Angle of Descent
  a. Aiming Points
    - The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
    - Select a point in front of the point of intended touchdown
        a. Approximately 400 to 500' in front of touchdown to allow for the airplane's float
            1. This is equal to 2 to 2½ stripes prior to your intended touchdown point
            2. This point will vary based on the aircraft, configuration, weight, and wind conditions.
    - Keep the aiming point steady on the wind screen
        a. To a pilot moving straight ahead toward an object, the aiming point appears to be stationary, it does not move.
        b. If the point begins to move up on the windscreen the airplane is getting too low
            1. Add power and raise the nose (maintain airspeed – the same airspeed with a higher power setting will result in a slower descent or climb)
        c. If the point begins to move down on the windscreen the airplane is getting too high
            1. Reduce power and lower the nose (maintain airspeed – the same airspeed with a lower power setting will result in a steeper descent)
        d. Small, active corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway
        e. Airspeed remains constant throughout the approach
  b. The Runway Image
    - Too High
        a. The runway will elongate and become narrower
            1. Overhead view of the runway
    - Too Low
        a. The runway will shorten and become wider
            1. Flat view of the runway



    - On Descent Path
        a. The runway will be between overhead and flat
        b. The runway shape remains the same but grows in size as we approach

iv. Objective of a Stabilized Approach

a. To select an appropriate touchdown point on the runway, and adjust the glidepath as necessary to roundout at or above the aiming point, providing distance for the flare to touchdown at the landing point

B. Energy Management
   i. A stabilized approach is based on well executed energy management
      a. As mentioned above, during the approach to final you are in the region of reverse command; power controls your rate of descent and pitch controls your airspeed
      b. A normal approach is based on a 3-degree glidepath (this translates to 300' per nautical mile). Therefore, you should be 300' above the touchdown zone elevation one mile from touchdown, and 600' two miles from touchdown
         - This should give you a general idea if you're on or off glidepath during the approach (if you're able to recognize your distance from the runway)
         - The ability to recognize a normal, 3-degree approach path comes with practice and experience
      c. Once configured for the approach, set the approximate pitch attitude and power setting for approach speed
         - The more familiar you are with the approximate pitch and power settings, the easier it will be to manage your energy and maintain a stabilized approach
         - Once the approximate pitch and power setting is established, trim the control forces and crosscheck the airspeed, altitude, and glidepath
         - Make adjustments to establish yourself on a 3-degree glidepath while maintaining approach speed
            a Increase power to decrease your rate of descent. A coordinated increase in pitch will be required to maintain approach speed
               1. Increased power without a change in pitch will increase airspeed
            b Decrease power to increase your rate of descent. A coordinated decrease in pitch will be required to maintain approach speed
               1. Decreased power without a change in pitch will decrease airspeed
            c The key to stabilized, well managed, approaches is coordinated inputs between pitch and power in order to maintain a 3-degree glidepath to your aiming point at approach speed
      d. "Go ugly early"
         - Make corrections early. Don't make a gradual correction to the glidepath or centerline of the runway, establishing yourself just prior to touchdown. This is unsafe.
            a You should be established on glidepath and course by 300'.
               1. This is a technique, but set a personal minimum where you will initiate a go around if you are not stabilized - on glidepath, airspeed, and runway course
         - If you realize you are off course (altitude or course), "go ugly early"
            a Make the necessary correction to reestablish yourself on glidepath and course as early as possible
            b The earlier you are stable, the safer the approach
               1. Of course, don't be overly aggressive with the aircraft at slow airspeeds near the ground.
            c For example, if you roll out a quarter to a half mile off centerline don't make a slow adjustment back to centerline, arriving just before touchdown. As soon as you see the mistake, make the required corrections to get established and stabilized early

1. Yes, the approach will look "ugly early" (you may have to make a considerable correction back to centerline) but it is far safer to be established early than not be stabilized close to the ground

3. Effects of Atmospheric Conditions, Including Wind, on Approach and Landing Performance

A. Density Altitude
   i. Density altitude is pressure altitude adjusted for non-standard temperature
   ii. Increased density altitude (lower pressure and/or higher temperature) increases the landing speed
      a. The aircraft lands at the same indicated airspeed, but because of reduced density (which can be a result of a lower pressure and/or a higher temperature), the true airspeed is greater
         - The higher the altitude, the higher the true airspeed (it takes a greater speed to create the same amount of lift in the thinner air at high altitude than the thicker air near sea level)

B. Wind
   i. Approach
      a. A headwind on approach decreases the aircraft's groundspeed. Because the aircraft is traveling at a slower speed, the rate of descent necessary to maintain a stable 3-degree path will need to be decreased as well
         - It will take longer to travel the same distance as if there was no wind, therefore the rate at which the aircraft descends needs to be reduced
      b. A tailwind on the other hand increases the groundspeed and because the aircraft is traveling at a higher-than-normal speed, the rate of descent to maintain a 3-degree path will need to be increased
   ii. Landing
      a. A headwind during landing helps to reduce the landing ground roll while a tailwind increases the ground roll
         - In both cases the aircraft touches down with the same indicated airspeed, but with a headwind, the aircraft touches down at a lower ground speed and therefore can stop sooner than an aircraft with a tailwind (higher groundspeed on touchdown)

4. Wind Correction Techniques on Approach and Landing

A. Crosswind Basics
   i. Imagine a 20kt headwind, directly down the runway
      a. On the downwind leg you're flying with a tailwind, and the groundspeed is 20 knots higher than true airspeed
         - The crosswind leg now has a significant crosswind and heading will have to be adjusted to maintain your track
         - On final, the aircraft will begin to slow as the crosswind turns into a headwind, slowing the aircraft 20 knots
            a A strong headwind slows your groundspeed, therefore the stronger the headwind, the lower your rate of descent to reach the runway
               1. The opposite applies, if you had a strong tailwind, you would need to descend faster since you are traveling faster than if you had zero wind or a headwind
         - Headwind on Approach = Slower descent rate (since you're traveling slower)
   ii. Crosswind Basics in the Pattern
      a. Adjust each leg to maintain a rectangle track – turn the aircraft into the wind to maintain the traffic pattern
      b. Crosswinds on the runway result in overshooting or undershooting winds in relation to your turn to final

- Imagine you are landing on runway 36 and have a wind from 060 degrees (a crosswind from the right on landing) this will result in an undershooting wind during the turn to final in left traffic and an overshooting wind in right traffic
    - a What this means is that using a normal amount of bank, as you make the turn to final the crosswind will either prevent you from reaching the runway centerline (undershooting) or push you past the runway centerline (overshooting)
    - b An undershooting wind will require less bank to align with the runway centerline and an overshooting wind will require more bank
        1. Always stay coordinated in your turns
- Basic Rule: On downwind, if the wind is blowing you away from the runway, you have an undershooting wind. If the wind is blowing you toward the runway, you have an overshooting wind. Adjust as necessary.

B. Landing

i. The principal effect of wind on landing distance is to change the groundspeed at which the aircraft touches down

a. A headwind decreases the groundspeed at which the aircraft touches down, thus decreasing the landing roll

b. A tailwind increases the groundspeed at which the aircraft touches down, thus increasing the landing roll

ii. Crosswind Corrections

a. Landing which must be made while the wind is blowing across rather that parallel to the landing direction

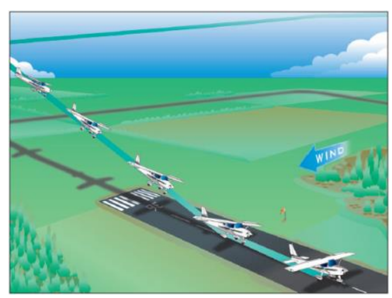
b. The same basic principles apply to a crosswind and normal approach and landing

c. Two methods of accomplishing a crosswind approach and landing

- Crab Method
    - a Easier but requires a high degree of judgment and timing in removing the crab right before touchdown
    - b Not recommended
- Sideslip (wing-low) Method
    - a Recommended

d. Final Approach

- Sideslip (Wing-Low)
    - a Align the airplane's heading with the centerline of the runway, noting the rate and direction of drift
    - b Promptly apply drift correction
        1. Lower the upwind wing
            a. Amount of lowering depends on the drift
            b. When the wing is lowered, the airplane will turn in that direction, so simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane in aligned with the runway



        2. The airplane will be side-slipping into the wind just enough so that the flight path and ground track are aligned with the runway
        3. Changes in the crosswind are corrected for accordingly
    - c Strong Crosswind
        1. In the case that it is not possible to maintain the centerline, the wind is too strong to safely land on the particular runway

a. There is insufficient rudder to maintain a heading with the required bank application
b. The landing should be made on a more favorable runway

d Maintain a stabilized approach
1. Same as normal, except with the added side slip
2. Because you are in a slip, drag is increased, more power will be necessary to maintain a given descent rate

e. Roundout
- Generally made like a normal landing approach, but the crosswind correction is continued as necessary to prevent drifting
  a Don't level the wings
  1. This will result in drifting, which results in side loading the gear
- Gradually increase the deflection of the elevators and rudder to maintain drift correction as the airplane slows
  a The controls become less and less effective as airspeed is decreased

f. Touchdown
- The touchdown should be made on the upwind main wheel first
  a Maintaining crosswind correction to prevent drift
- As the momentum decreases, the weight of the airplane will cause the downwind main wheel to gradually settle onto the runway, then the nosewheel

g. After Landing Roll
- Maintain directional control with rudders
  a With a greater profile behind the main wheels, the airplane will tend to weathervane into the wind
- Maintain crosswind control with ailerons
  a Full aileron into the wind
  1. Keeps the upwind wing from rising
  b As the speed decreases, increasing aileron is going to be necessary

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

A. Pilot Capability
i. Not only should a pilot have personal weather minimums, but also runway minimums
a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
c. These limitations may vary based on whether the runway is wet or dry or other factors

B. Aircraft Performance and Limitations and the Available Distance
i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
a. Do not attempt to takeoff or land from a runway that is not supported by the landing data

b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe approach and landing
    - Take into account the runway distance available as well as potential obstacles on the approach or in the case of a go around

ii. Do not exceed any flight limitations – follow the flight manual

iii. Calculate landing distance based on the current atmospheric conditions using the manufacturer's landing distance tables
  a. Using METAR and TAF information (depending on when you intend to land) obtain landing distance with the landing distance charts in the flight manual
  b. The landing distance should be compared to the runway available
  c. Landing Distance will vary based on factors such as weight, density altitude, runway surface and gradient, wind conditions, etc.

iv. Factors affecting Landing Distance
  a. Weight
    - Higher weights increase landing distance
  b. Wind
    - Increased Headwinds decrease landing distance
  c. Pressure/Density Altitude
    - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases landing distance
  d. Runway Slope and Condition
    - An inclined runway will decrease landing distance
    - Different types of runways can affect the landing distance
      a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual

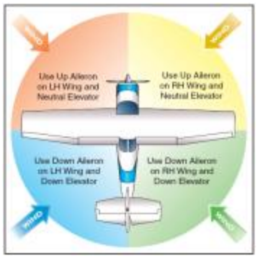
C. The most favorable runway for landing meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
  i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
    a. This runway may be more favorable because it is aligned with your arrival direction, it may be a shorter taxi, it may be a longer runway, or it may provide a safer approach or climb out in the case of a go around
      - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

2. Crosswind

A. While usually preferable to land directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind
  i. See above for information on how to handle crosswinds safely
    a. The main idea is to use the ailerons to keep the aircraft centered on the runway and use the rudder to keep the longitudinal axis of the aircraft lined up with the centerline of the runway. This is to keep the aircraft on the runway and prevent damaging the gear

B. Crosswinds and Taxiing
  i. Taxiing with a tailwind
    a. Usually will require less engine power after the initial ground roll is begun
    b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally

ii. Taxiing with a quartering headwind



a. Ailerons are turned into the headwind and the elevator is held neutral

b. 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

c. Also, the downwind aileron will be DOWN
   - A small amount of lift/drag is put on this wing keeping the upwind wing down

iii. Taxiing with a Quartering Tailwind

a. Ailerons are turned with the wind and the elevator is DOWN
   - Dive with the Wind
   - This reduces the tendency of the wind to nose the plane over
   - The upwind aileron is DOWN in this case (opposite of a head wind)

iv. These corrections minimize weathervaning and provide easier steering

v. Always know the direction of the wind in relation to the airplane

a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Maximum Demonstrated Crosswind Component

i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft

a. Prior to landing use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
   - If this exceeds the maximum demonstrated crosswind component, landing is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used

b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?

i. Unexpected change in wind direction and/or wind speed

ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?

i. It is often associated with thunderstorms

a. Microbursts
   - These can be extremely dangerous

ii. Inversion layer

a. Sometimes an inversion layer will result in a wind shift during descent

C. Dealing with it

i. Avoid It!

a. DO NOT FLY if there is potential for wind shear

b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm

c. LLWAS (Low Level Wind Shear Alerting System)
   - Most major airports have an LLWAS
   - If available, it can warn of impending wind shear
   - PIREPS can be very informational

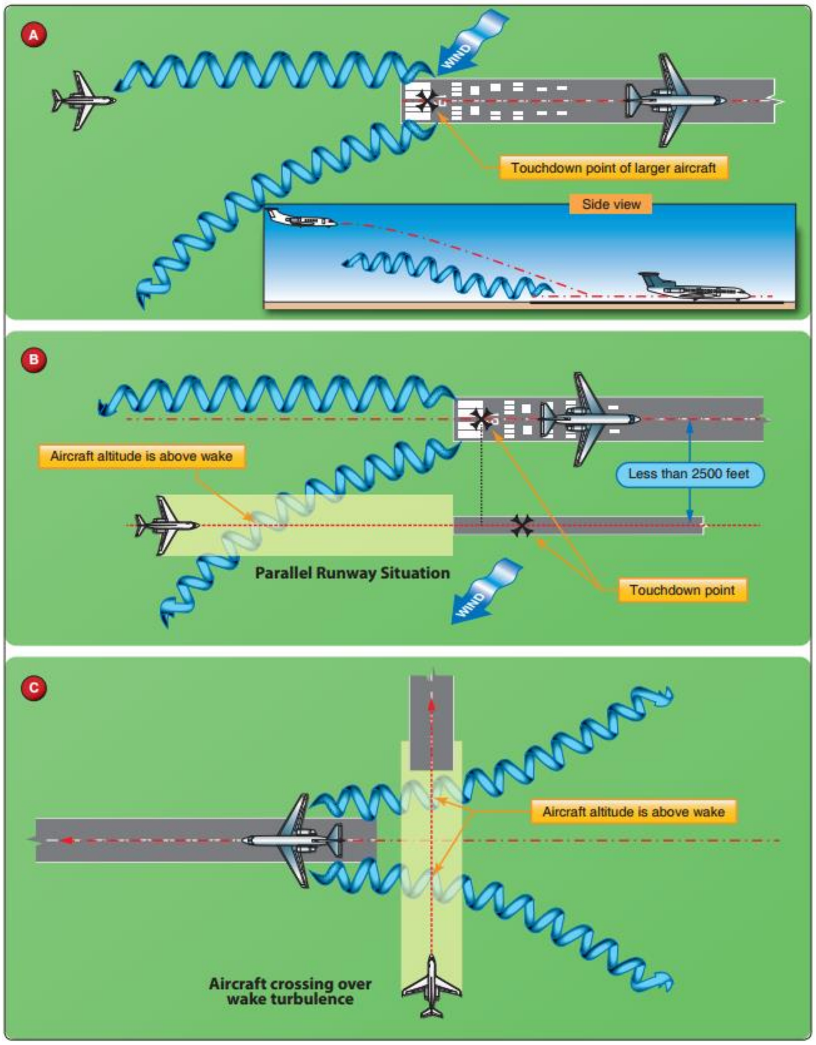
            - a Direct reports from other pilots who experienced the wind shear
    - ii. Approach into Wind Shear
        - a. If an option, divert to an airport with favorable weather conditions, otherwise,
            - Use more power
            - Maintain a Faster approach airspeed
                - a Add ½ the gust factor to the approach speed
            - Stay as high as feasible until necessary to descend
            - Go Around at the first sign of a change in airspeed or unexpected pitch change
                - a Important to get FULL power and get the aircraft into a max performance climb

4. Tailwind

- A. A tailwind increases the runway required for landing
    - i. Always verify the wind conditions and landing performance obtained are compatible with the runway of intended use
- B. The flight manual will publish a maximum tailwind for landing, do not exceed this limit
- C. Use the performance charts to verify takeoff performance with the projected winds

5. Wake Turbulence

- A. All aircraft generate wake turbulence during flight.
    - i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
    - ii. The vortices from larger aircraft pose problems to aircraft encountering them
        - a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft
- B. Wake Turbulence Recognition in the Terminal Area
    - i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
    - ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
        - a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft
- C. Wake Turbulence Resolution
    - i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
        - a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
        - b. Crossing runways – cross above the larger jet's flight path
    - ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. **Runway Surface/Condition**
   A. Runway conditions affect takeoff performance
      i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces
   B. Surface
      i. Runway surfaces vary widely. The runway surface may be concrete, asphalt, gravel, dirt, or grass
         a. The runway surface for a particular airport can be found in the Chart Supplement
         b. Any surface that is not hard (grass, dirt, etc.) decreases the ground roll during landing
            - Tires sink into soft runways and the tires do not roll smoothly over the surface
      ii. Braking effectiveness is another consideration when dealing with different runway types
         a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft
      iii. The gradient of the runway can also have an effect on the landing ground roll
         a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3’ for every 100’ of runway length
         b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
         c. An upsloping runway assists deceleration and decreases the takeoff roll
   C. Condition

i. Braking effectiveness comes into play for different runway conditions
    a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to stop the aircraft
        - Water decreases the friction between the tires and the ground, reducing braking effectiveness
        - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway's surface – braking and directional control are almost nil.
            a Grooved runways help to reduce hydroplaning
            b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
        - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
            a Use aerodynamic braking to its fullest advantage

D. Length
    i. Runway length obviously needs to accommodate the landing distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
    ii. Never attempt a landing on a runway that is not supported by the landing data
    iii. Ensure that runways are adequate in length for landing when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for:

A. Rejected Landing and Go-Around
    i. General
        a. Depending on the situation you may have to choose between a go around to handle an emergency airborne or continuing to land.
            - Go Around
                a There are situations that can be better handled airborne than on the ground
                    1. If you get an emergency close to the ground (that doesn't affect the aircraft's ability to fly) and could create a hazard during landing, whether as a distraction or in relation to the safety of the aircraft it may be better to go around
                    2. For example: landing gear problems. Go around and attempt to solve the problem airborne
            - Continue to Land
                a There are many situations that can be better handled by continuing the landing instead of going around to attempt to fix the problem
                    1. If you experience an emergency that can affect the airplane's ability to fly, it is likely best to continue to land the aircraft
                    2. For example: if the engine starts running rough at 500', do not attempt to go around as it may exacerbate the problem and quickly lead to an emergency landing
        b. This is a very basic, surface level discussion as to whether go around or continue to land. These emergencies are aircraft and situation dependent, there may not necessarily be a correct procedure (go around or land), and depends on the pilot in commands discretion
        c. Hindsight is always 20/20. Take time to review and learn from NTSB accident reports, and consider how you would handle different situations.
    ii. Go Arounds Are Free
        a. If you're ever in doubt of the safety of the approach, go around
        b. Maintain a stabilized approach

- Stable means on airspeed, glidepath, and runway centerline
    a Momentary deviations from speed, glidepath and centerline are acceptable
- Set limits for airspeed/altitude requirements and an altitude at which if you are outside any of these limits you will go around – no questions asked
    a For example, ±5 knots and within 50’ of altitude within a half mile of the runway (150’ AGL)
        1. Assuming a 3-degree glidepath, you should be 300’ AGL one mile out and 600’ AGL 2 miles out, etc. Unless you have ground references at these points, recognizing this will come with experience
        2. If you are outside of these tolerances, the approach is unstable and it is time to go around

iii. Delaying the go-around often stems from two sources:
   a. Landing expectancy
      - The set anticipatory belief that conditions are not as threatening as they are and that the approach will surely end with a safe landing
   b. Pride
      - The mistaken belief that a go around is an admission of failure
   c. Understand these conditions and don’t let them influence your decision to go around

B. Land and Hold Short Operations (LAHSO)
   i. LAHSO operations may be in effect when simultaneous operations are being conducted on intersecting runways
      a. The idea is to allow simultaneous takeoffs and landings on intersecting runways
      b. ATC will clear an aircraft to land and hold short (stop before crossing the intersecting runway) to allow use of the intersecting runway
         - Runway holding position signs and markings are installed on runways prior to the intersection at which you need to hold short
   ii. As Pilot in Command, you have the final authority to accept of decline any LAHSO clearance
      a. You are never required to accept the clearance, if you are uncomfortable simply reply “unable” to ATC
      b. If you accept a LAHSO clearance you must comply so that no portion of the aircraft extends beyond the hold markings
   iii. The holding position sign has a white inscription with a black border around the numbers on a red background and is installed adjacent to the holding position markings
   iv. 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. Know what signs and markings are at the LAHSO point
      e. LAHSO are not authorized for student pilots who are performing a solo flight
      f. At many airports, air carriers are not authorized LAHSO if the other aircraft is general aviation
      g. Generally, LAHSO are not authorized at night
      h. LAHSO are not authorized on wet runways

8. Collision Hazards

A. Collision Avoidance
   i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in

conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
        - If they are different categories:
            a A balloon has the right of way over any other category
            b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
            c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
            d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    c. Approaching Head-on
        - Each pilot shall alter course to the right
    d. Overtaking
        - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    e. Landing
        - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
            a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
        - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
            a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
    a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
        - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
        - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
    a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
    b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
        - This is also more applicable to cruise, but can be used while the pattern, if necessary
    c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

        a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
            - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
    i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
        a. Study sectionals and terminal area charts
        b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
        c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
    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
            - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
        b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
    i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
        a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
        b. Become familiar with any obstacles on the approach and departure path
        c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
        d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
        e. NOTAMs are issued on lighted structures experiencing light outages
    ii. Antenna Towers
        a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
            - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing
    iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
        a. Ensure proper clearance between the aircraft and obstacle
            - If unsure of clearance, stop until you're sure it is safe to pass
    v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.
    i. Be alert for anyone/anything that may cause a hazard
        a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
            - Be cautious

- Initiate a go-around, if required

b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
   - It may be necessary to go-around in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering/Stall/Spin

A. Low Altitude Maneuvering

i. A small problem at high altitude can quickly become a big problem at a low altitude

a. There is considerably less time to handle any issues at a low altitude

b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
   - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)

ii. Be aware of, and avoid obstructions on and around the airfield

a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground

b. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin

i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.

a. Airspeed
   - Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach.
     - a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
   - If you get any indication of a stall at low level, recover from the stall and go around
     - a Max, Relax, Roll is a common memory aid for stall recovery
       1. Apply max power
       2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
       3. And roll wings level

b. Cross Controlled Stall
   - Here's a situation that will lead to a cross-controlled condition in the pattern:
     - a In a descent, the pilot starts the left turn from base to final late, additionally there's an overshooting wind pushing the aircraft past the runway centerline and potentially into the final approach of a parallel runway
     - b In order to attempt to fix the problem, the pilot rolls to 30° of bank, knowing that is the limit for safe bank in the pattern, but 30° of bank is not enough to line aircraft up with the centerline, an overshoot is inevitable
       1. In order to correct, and avoid the parallel runway's final approach area, the pilot adds left rudder (trying to force the airplane around the corner and avoid the overshoot), while maintaining 30° of bank
          a. The left rudder pushes the nose around, and also increases lift on the right wing (the yaw swings the right wing around, moving it faster than the left, increasing lift)
          b. As lift increases on the right wing, the aircraft rolls left, the pilot applies right aileron to maintain 30° of bank

i. The aircraft is now in an uncoordinated cross-controlled situation - Left rudder and right aileron

c This can quickly lead to a very dangerous cross-controlled stall. One in which the aircraft may roll over (almost, if not fully inverted). The natural reaction of rolling in the opposite direction only intensifies the stall. This is likely unrecoverable at low altitudes. Maintain coordination!

ii. Spin
  a. A spin is a result of a stall + yaw
    - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
  b. Prevention
    - Maintain coordination
    - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
    - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
  d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. The majority of CFIT incidents occur during final approach and landing
    b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
    c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
  iii. Recommendations:
    a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
    b. Know and fly above minimum published safe altitudes.
      - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
    c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
    d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
    e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
    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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

- A. Distractions
    - i. In the descent, approach, traffic pattern, and landing, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.
    - ii. At a controlled field, listen to ATC's instructions
        - a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
    - iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
    - iv. Fly first!
        - a. Aviate, Navigate, Communicate
    - v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
    - vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
        - a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing
- B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air
    - i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    - ii. There is no place for distractions in the traffic pattern and in the runway environment
    - iii. Maintain situational awareness
        - a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem
- C. Task Management
    - i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
        - a. No one responsibility should take your full attention full more than a short period
            - Continually move between tasks to ensure everything is being taken care of
        - b. Safety is your number one priority
            - Aviate, Navigate, Communicate
    - ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        - a. Checklists are extremely helpful in properly managing tasks
    - iii. Recognize when you are getting behind the aircraft, and find a way to catch up
        - a. If more time is needed, go around, find somewhere to hold/circle, or slow down
        - b. Ask for assistance, if possible
        - c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.

2. Make radio calls as appropriate.
3. Ensure the aircraft is aligned with the correct/assigned runway
4. Scan the landing runway and adjoining area for traffic and obstructions
5. Consider the wind conditions, landing surface, obstructions, and select a suitable touchdown point.
6. Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
7. Maintain manufacturer's recommended approach airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots, or as recommended for the aircraft type and gust velocity.
8. Maintain crosswind correction and directional control throughout the approach and landing.
9. Make smooth, timely, and correct control inputs during round out and touchdown.
10. 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.
11. Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
12. Utilize runway incursion avoidance procedures.

IV.C. Soft-Field Takeoff and Climb

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Effects of Atmospheric Conditions, Including Wind, on Takeoff and Climb Performance**
   - A. Atmospheric conditions greatly affect takeoff distance
     - i. Pressure Altitude
       - a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
         - $1{,}000(29.92 - \text{Alt}) + \text{Elev}$
       - b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
         - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
           - a Therefore, aircraft takeoff and climb performance will improve with higher air pressure (shorter takeoff distance, and increased climb performance)
         - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather
     - ii. Density Altitude/Temperature
       - a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
         - $120(°\text{C} - 15°\text{C}) + \text{PA}$ (this is an approximation)
       - b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
         - Lower temperatures (the air is more compressed) result in better performance
         - Higher temperatures (the air is less compressed) result in poorer performance
         - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
           - a Lower temperatures result in better performance (shorter takeoff run and increased climb performance)
           - b Overall, high pressure, cold days result in the best takeoff and climb performance
     - iii. Humidity
       - a. Although not directly accounted for on the performance charts, humidity decreases performance
   - B. Wind Conditions and Effects
     - i. Wind and Takeoff Distance
       - a. The effect of wind on takeoff distance is large, and proper consideration must be given when predicting takeoff distance
       - b. A headwind allows the aircraft to reach lift-off speed at a lower groundspeed
         - There is wind moving over the wings while the aircraft is standing still, thus the aircraft can leave the ground at a lower ground speed
       - c. A tailwind requires the aircraft reach a higher groundspeed to reach lift off speed
         - If there is a 10-knot tailwind, the aircraft has to accelerate to 10 knots before the speed of the air over the wings reaches 0 knots
     - ii. Headwinds also increase the aircraft's ability to climb

        a. Greater airflow over the wings results in increased lift and therefore increased climb performance
        b. A headwind also decreases the aircraft's groundspeed allowing the aircraft to climb to a given altitude in a shorter distance

2. **V_X and V_Y**
    A. V_X: The speed at which the aircraft obtains the highest altitude in a given horizontal distance. The best Angle of Climb (AOC) speed normally increases slightly with altitude.
        i. An example of when max AOC is used, is when taking off from a short airfield surrounded by high obstacles (trees, power lines, etc.)
        ii. V_X occurs at the airspeed and angle of attack combination which allows for the maximum excess thrust
    B. V_Y: The speed at which the aircraft obtains the maximum increase in altitude per unit of time. The best Rate of Climb speed normally decreases slightly with altitude.
        i. V_Y depends on excess power and occurs at the airspeed and angle of attack combination that produces the most excess power.
            a. Since climbing is work, and power is the rate of performing work, a pilot can increase the climb rate by using any power not used to maintain level flight
3. **Appropriate Aircraft Configuration**
    A. The configuration will be based on the aircraft manufacturer flight manual
        i. Wing flaps may be lowered prior to starting the takeoff (if recommended by the manufacturer) to provide additional lift and transfer the aircraft's weight from the wheels to the wings as early as possible
4. **Ground Effect**
    A. What is it?
        i. During takeoff/landing when you are flying very close to the ground, the earth's surface actually alters the three-dimensional airflow pattern around the airplane because the vertical component of the airflow around the wing is restricted by the ground surface
            a. This causes a reduction in wingtip vortices and a decrease in upwash and downwash
            b. Since the ground effect restricts downward deflection of the airstream, induced drag decreases
    B. Effects on Flight
        i. Takeoff
            a. With the reduction of induced drag, the amount of thrust required to produce lift is reduced
                - Therefore, the airplane 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 the normal takeoff speed you might sink back to the surface
    C. Ground Effect and Soft-Field Takeoffs
        i. The motion of 'popping' the plane into ground effect and remaining there can be hazardous
            a. A smooth, stable hand is needed in order to quickly transfer the weight from the wheels to the wings and then lower the nose in order to remain in ground effect, without a resulting tail strike or nosewheel/prop strike
                - Experience and smooth control inputs are key to the soft-field takeoff
                - As the aircraft accelerates, lift increases, it is necessary to lower the nose further in order to stay in ground effect
                    a Be smooth and stable. Rapid, jerky movements can be hazardous
5. **Importance of Weight Transfer from Wheels to Wings**
    A. One of the goals of a soft or rough field takeoff is to transfer as much weight as possible to the wings and take advantage of ground effect

i. Drag
    a. Soft surfaces, grass, etc. reduce the airplane's acceleration during the takeoff roll so much that adequate takeoff speed may not be attained in a normal takeoff
ii. Damage
    a. Due to the roughness of these fields, it is advised to get the aircraft off the ground as soon as possible to avoid damaging the gear and avoiding a potential incident
iii. Taxi
    a. During taxi, maintain full back pressure (assuming that's safe for your aircraft) to keep weight off the nosewheel and prevent getting bogged down in the soft surface
iv. Takeoff
    a. As the aircraft accelerates, enough back-elevator pressure should be applied to establish a positive angle of attack and to reduce the weight supported by the nosewheel
    b. When the aircraft is held at a nose-high attitude throughout the takeoff run, the wings will, as speed increases and lift develops, progressively relieve the wheels of more and more of the aircraft's weight, minimizing the drag caused by the soft-field surface
    c. If maintained, the aircraft will fly itself off the ground, becoming airborne at an airspeed slower than a safe climb speed due to ground effect

B. The Takeoff and Liftoff
  i. Takeoff
    a. Determine the crosswind condition and apply the appropriate correction
      - Done the same as a normal takeoff
    b. Maintain back elevator pressure and maintain movement
      - Don't let the nose wheel settle or allow the aircraft to come to a stop
    c. While aligning the aircraft with the centerline, takeoff power is accelerated smoothly and rapidly
      - Don't stop to align the aircraft with the centerline
      - Cross check engine indications for proper operation after applying power
      - Use proactive rudder pressure to counteract the yawing forces and keep the airplane moving straight down the center of the runway
    d. The initial momentum required for takeoff is going to require much more power than normal - Anticipate a slow acceleration
    e. Back elevator pressure is initially held full aft
      - As the plane accelerates and the nose lifts off the ground the elevator pressure is relaxed as necessary to maintain a nose high pitch attitude keeping the nose wheel off the ground
        a Maintaining full back pressure during acceleration would result in the tail striking the ground
        b As speed increases, back pressure must be reduced to avoid an excessive angle of attack
          1. Too much back pressure can increase drag or drag the tail
        c It's very important to continue to use rudder to control direction
          1. Remember that an increase in the angle of attack will result in an increase in P-Factor and therefore more rudder will be required to keep the aircraft straight
      - With the nose-high attitude throughout the takeoff run, the wings will, as speed increases and lift develops, progressively relieve the wheels of more and more of the airplane's weight
        a This minimizes the drag caused by the soft, unstable surface
      - The airplane will effectively fly itself off the ground at a speed slower than the normal rotation speed because of ground effect

ii. Lift-Off
   a. After the airplane initially becomes airborne, the nose should be lowered gently with the wheels clear of the surface to allow the airplane to accelerate to V_X or V_Y in ground effect
      - V_X is used if an obstacle must be cleared
      - Smoothly apply forward pressure to keep the aircraft close to the ground
         - a Be smooth - Abrupt/excessive control movements could easily put the aircraft back into the ground
   b. Site Picture: The nose will be point further downward, toward the runway, as airspeed, and lift increase
      - Forward pressure is required to stay in ground effect
         - a Forward pressure combined with the nose pointing down while close to the ground can be very uncomfortable, especially to a new pilot, but it is extremely important to stay in ground effect until a safe climb speed has been reached
   c. Trying to climb out of ground effect too early or too steeply may result in the airplane settling back onto the surface
      - In ground effect, the vertical component of the airflow about the wing is restricted
         - a Alters upwash, downwash, and wingtip vortices
      - Reduces Induced Drag
         - a Requiring a lower angle of attack and less required thrust
      - For ground effect to be effective, the wing must be within ½ of its wingspan of the ground
         - a If the airplane tries to climb out of ground effect without enough speed, the greater induced drag may result in marginal to no climb performance
   d. The airplane must remain in ground effect until at least V_X is reached

6. Left Turning Tendencies

A. Asymmetric Loading (P Factor)
   i. When flying with a high angle of attack, 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. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc
      a. At positive angle of attack, the right blade is passing through an area of resultant velocity greater than the left
      b. 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
   iii. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)
      a. If there were no air movement at all, except that generated by the prop, 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
         - The blade proceeding is creating more lift or thrust, moving the center of lift toward it
      c. Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
         - The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow
   iv. Summary: The descending blade of the propeller has a higher angle of attack, resulting in a bigger bite of air, therefore the center of thrust is moved to the right side of the aircraft's centerline and the aircraft will have a tendency to yaw to the left

B. Compensating for P-Factor
   i. Right rudder is required to compensate for the left yawing tendency of P-Factor

ii. The amount of rudder varies directly with the amount of power and the angle of attack
    a. Higher power settings, and higher angles of attack create more yaw and therefore require more rudder to maintain coordination
        - EX: Slow flight – high power and high angle of attack = a lot of right rudder
    b. The amount of rudder to apply will become more familiar with experience allowing the pilot to focus more attention outside and to flying the plane rather than on maintaining coordination

C. P-Factor and Soft-Field Takeoffs
    i. During the takeoff roll, back elevator pressure is maintained in order to move the weight off the wheels and on to the wings. This results in the aircraft traveling down the runway at a high angle of attack, thus increasing P-Factor and the amount of right rudder required on takeoff
        a. Right rudder will need to be increased as the nose raises

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

A. Pilot Capability
    i. Not only should a pilot have personal weather minimums, but also runway minimums
        a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
        b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
        c. These limitations may vary based on whether the runway is wet or dry or other factors
        d. Be very competent with soft-field procedures prior to attempting them on your own

B. Aircraft Performance and Limitations and the Available Distance
    i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
        a. Do not attempt to takeoff or land from a runway that is not supported by the landing data
        b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe takeoff and climb
            - Take into account the runway distance available as well as potential obstacles on climb out
        c. Do not exceed any flight limitations – follow the flight manual
    ii. The minimum takeoff distance is obtained by taking off at some minimum safe speed for the current conditions that allows sufficient margin above stall and provides satisfactory control and initial rate of climb
        a. Generally, the lift-off speed is some fixed percentage of the stall speed or minimum control speed
    iii. Calculate Takeoff Distance based on the current atmospheric conditions using the manufacturer's takeoff distance tables for a Soft-Field Takeoff
        a. Using the local weather information (METAR, TAF, etc. depending on when you intend to takeoff) obtain takeoff distance with the performance charts in the flight manual
        b. The takeoff distance should be compared to the runway available
    iv. Factors affecting Takeoff Distance
        a. Weight

- Higher weights increase takeoff distance

b. Wind
   - Increased Headwinds decrease takeoff distance

c. Pressure/Density Altitude
   - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases takeoff distance

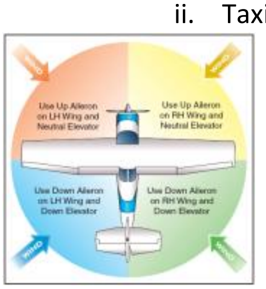
d. Runway Slope and Condition
   - An inclined runway will increase takeoff distance
   - Different types of runways can affect the takeoff distance
     a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction to overcome on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual.

C. The most favorable runway for takeoff meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
   i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
      a. This runway may be more favorable because it is aligned with your departure direction, it may be a shorter taxi, it may be longer, or it may provide a safer climb
         - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

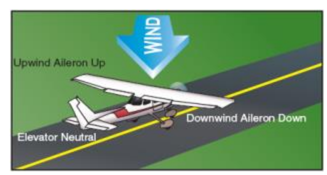
2. Crosswind

A. While usually preferable to takeoff directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind

B. Crosswinds and Taxiing
   i. Taxiing with a tailwind
      a. Usually will require less engine power after the initial ground roll is begun
      b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally
   ii. Taxiing with a quartering headwind



Ailerons are turned into the headwind and the elevator is held neutral



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

Also, the downwind aileron will be DOWN
   - A small amount of lift/drag is put on this wing keeping the upwind wing down

   iii. Taxiing with a Quartering Tailwind
      a. Ailerons are turned with the wind and the elevator is DOWN
         - Dive with the Wind
         - This reduces the tendency of the wind to nose the plane over
         - The upwind aileron is DOWN in this case (opposite of a head wind)

   iv. These corrections minimize weathervaning and provide easier steering
   v. Always know the direction of the wind in relation to the airplane
      a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Crosswinds and Takeoff
   i. Taxi onto the Runway

a. Before taxiing onto the runway adequately clear the area; do not taxi onto the runway if it is not safe
b. The airplane should be carefully aligned with the intended takeoff direction, and the nose wheel positioned straight, or centered

ii. If a crosswind is indicated (windsock, ATIS, other direction indicators) full aileron should be held into the crosswind as the roll is started
   a. This raises the aileron on the upwind wing to impose a downward force on the wing counteracting the lifting force of the crosswind and preventing the wing from raising
   b. With the aileron into the wind, the rudder should be used to keep the takeoff path straight
      - Rudder in the direction opposite of the aileron input is required to keep the takeoff path straight

iii. Gaining Speed
   a. As the forward speed is increased, the crosswind becomes more of a relative headwind and the air moving faster over the flight controls causes them to be more effective, therefore full aileron pressure into the wind should gradually be reduced
      - Some aileron pressure will need to be maintained – It doesn't all go away
         a Don't be mechanical in the use of aileron control, rather sense the need for varying aileron control input through feel for the plane and visual indications
         b Don't use excessive aileron input in the latter stage of the takeoff roll, this can result in a steep bank into the wind at lift-off (putting the wing near the runway surface)
            1. Slowly reduce aileron pressure as the crosswind becomes more of a relative headwind and the control surfaces become more effective

iv. Avoid an early lift-off resulting in side-skipping
   a. If the correction is not held properly, a skipping action may result
      - Indicated by a series of very small bounces
   b. Side-skipping imposes severe side stresses on the landing gear and could result in structural failure

v. Lift-Off
   a. In a significant crosswind, hold the main gear on the ground longer to ensure a smooth but definite takeoff
      - Leave the ground with more positive control and prevent side loading on the landing gear
   b. It is important that sufficient aileron is held into the wind so that immediately after liftoff the aircraft is side slipping into the wind to counteract drift
      - 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
         a This is acceptable and preferred to side skipping
   c. Once the plane leaves the ground drift correction needs to be maintained
      - Visually
         a The runway will begin to disappear as the nose pitches upward
         b Maintain the centerline as well as airplane pitch and bank with outside references and instrument indications
      - Instrument Indications
         a Pitch to maintain V_Y (or whatever speed required for the situation)
            1. Make small adjustments as necessary for airspeed

D. Maximum Demonstrated Crosswind Component
   i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft

a. Prior to takeoff use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
    - If this exceeds the maximum demonstrated crosswind component, takeoff is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used

b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?
  - i. Unexpected change in wind direction and/or wind speed
  - ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?
  - i. It is often associated with thunderstorms
    - a. Microbursts
      - These can be extremely dangerous
  - ii. Inversion layer
    - a. Sometimes an inversion layer will result in a wind shift during descent

C. Dealing with it
  - i. Avoid It!
    - a. DO NOT FLY if there is potential for wind shear
    - b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
    - c. LLWAS (Low Level Wind Shear Alerting System)
      - Most major airports have an LLWAS
      - If available, it can warn of impending wind shear
      - PIREPS can be very informational
        - a Direct reports from other pilots who experienced the wind shear
  - ii. Wind Shear after Takeoff
    - a. If possible, land straight ahead on the remaining runway
    - b. If not, increase to max power, and begin a maximum performance climb
      - Be aware that the aircraft may not fly, you may be forced to land

4. Tailwind

A. A tailwind increases the runway required for takeoff
  - i. Always verify the wind conditions and takeoff performance obtained are compatible with the runway of intended use

B. The flight manual will publish a maximum tailwind for takeoff, do not exceed this limit

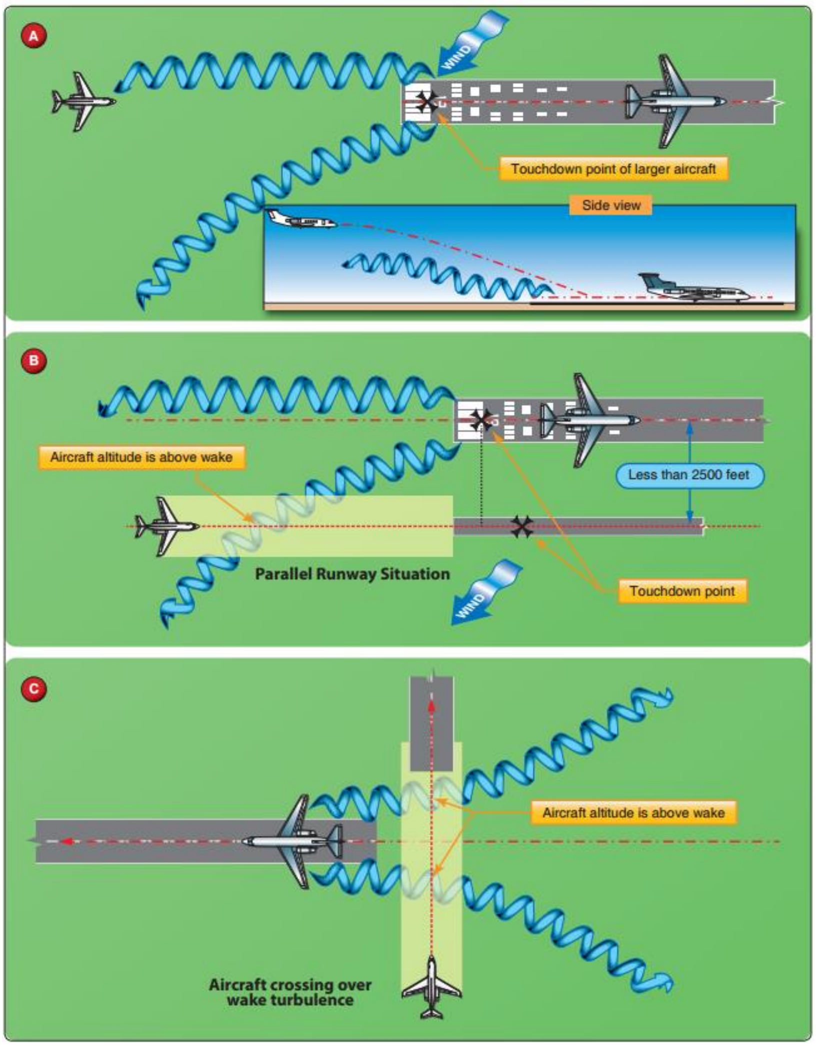
C. Use the performance charts to verify takeoff performance with the projected winds

5. Wake Turbulence

A. All aircraft generate wake turbulence during flight.
  - i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
  - ii. The vortices from larger aircraft pose problems to aircraft encountering them
    - a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft

B. Wake Turbulence Recognition in the Terminal Area
  - i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)

   ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
      a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft
C. Wake Turbulence Resolution
   i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
      a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
      b. Crossing runways – cross above the larger jet's flight path
   ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. Runway Surface/Condition

A. Runway conditions affect takeoff performance
   i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces

B. Surface
   i. Runway surfaces vary widely. In this case, the runway will likely be grass or dirt
      a. The runway surface for a particular airport can be found in the Chart Supplement
      b. Any surface that is not hard (grass, dirt, etc.) increases the ground roll during takeoff
         - Tires can sink into soft runways and the tires do not roll smoothly over the surface
         - Use the soft field procedures to compensate for the runway surface since aircraft acceleration is reduced so much that adequate takeoff speed may not be attained if normal takeoff techniques were employed
   ii. Braking effectiveness is another consideration when dealing with different runway types
      a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft
   iii. The gradient of the runway can also have an effect on the takeoff ground roll
      a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3' for every 100' of runway length
      b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
      c. An upsloping runway impedes acceleration and increases the takeoff roll
   iv. Takeoffs and climbs from soft fields require the use of operational techniques for getting the aircraft airborne as quickly as possible to eliminate the drag caused by tall grass, soft sand, mud, and snow.
      a. These softer surfaces reduce the aircraft's acceleration during the takeoff roll
         - Stopping on a soft surface, such as mud or snow, might bog the aircraft down; therefore, it should be kept in motion with sufficient power while taxiing and lining up for the takeoff roll

C. Condition
   i. Obstructions such as mud, snow, or standing water also reduce the aircraft's acceleration down the runway
      a. Dry runways provide the best acceleration
   ii. If the nose digs into the soft surface at high speeds it can result in the aircraft cartwheeling
      a. Always maintain back pressure and be very cautious with hard brake applications

D. Length
   i. Runway length obviously needs to accommodate the takeoff distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
   ii. Never attempt a takeoff on a runway that is not supported by the takeoff data
   iii. Ensure that runways are adequate in length for takeoff acceleration and deceleration when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for Rejected Takeoff and Engine Failure in Takeoff/Climb Phase of Flight

A. Always have a plan before starting the takeoff roll. Brief that plan
   i. The Air Force and airlines will brief every departure. The brief reviews the standard procedures, expected procedures and actions, as well as intentions in the case of an emergency during takeoff
      a. Prior to rotate speed, plan to keep the aircraft on the ground (assuming the runway distance allows this)
      b. From rotation to a certain point (runway distance allowing) you may be able to attempt to land on the remaining in the case of an engine failure. After this point, it will be unfeasible to land on the runway.
         - Use the distance remaining signs along the runway edges to know when it is too late to return
      c. Brief an altitude at and above which, you will turn around to return to the airport for landing

d. Between the point at which you can no longer land on the remaining runway (a) and the point at which you have the altitude to return to the airport (b) you will have to land on the most suitable surface outside of the airport

B. Rejected Takeoff
   i. Circumstances such as engine malfunctions, inadequate acceleration, runways incursion, ATC conflict, or any other emergency can result in a takeoff having to be rejected on the runway
      a. Inadequate Acceleration
         - Prior to takeoff, the pilot should have in mind a point along the runway at which the airplane should be airborne. If that point is reached and the airplane is not airborne, immediate action should be taken to reject the takeoff
      b. Rejected Takeoff Procedures
         - Follow the procedures as specified the manufacturer’s flight manual
         - Generally, the pilot will reduce power to idle, and apply maximum braking while maintaining directional control
            - a On a soft-field takeoff, weigh the consequences of applying maximum braking on the soft runway surface
               1. Hard braking could result in the nosewheel forcefully returning to the ground and a cartwheeling aircraft
         - If it is required to shut down the engine due to a fire, or for any other reason, the mixture control should be brought to the idle cutoff position and the magnetos turned off. Follow the manufacturer’s emergency checklist

C. Engine Failure
   i. Time is of the essence
      a. In most instances the pilot only has a few seconds after engine failure to decide what course of action to take and to execute those actions
      b. Unless prepared in advance to make the proper decision, there is an excellent chance that the pilot will make a poor decision or no decision at all
   ii. Procedures
      a. The first responsibility is to maintain aircraft control
      b. During the takeoff roll, reject the takeoff and stop straight ahead
         - Be very cautious with firm brake applications as it could forcefully put the nosewheel into the ground, resulting in a cartwheeling aircraft
      c. Immediately following takeoff, if there is sufficient runway available straight ahead, land on the remaining runway
         - Ensure you know how much runway you need (descent + landing distance)
            - a Use soft-field landing techniques
      d. During the takeoff climb
         - During the takeoff climb, the aircraft will have full power, a high pitch attitude and right rudder
         - When the engine fails, the pilot must immediately lower the nose (to the best glide speed) to prevent a stall and/or spin, and release the right rudder since the turning tendencies have been removed
            - a If the engine doesn’t totally fail, some right rudder may be necessary to maintain coordination
         - Once the pilot has control of the aircraft, establish a controlled glide toward a plausible landing area (preferably straight ahead on the remaining runway)

- During climb, know at what altitude you can return to the field and what options you have other than the airfield

8. Collision Hazards

A. Aircraft

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
  - a A balloon has the right of way over any other category
  - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
  - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
  - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on

- Each pilot shall alter course to the right

d. Overtaking

- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing

- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
  - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
  - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:

- 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

- iv. Clearing Procedures
  - a. Before Takeoff: Scan the runway and final approach for other traffic
  - b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
- v. Scanning
  - a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
- i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
  - a. Study sectionals and terminal area charts
  - b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
  - c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
- 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
    - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
  - b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
- i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
  - a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb after takeoff
  - b. Become familiar with any obstacles on the approach and departure path
  - c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
  - d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
  - e. NOTAMs are issued on lighted structures experiencing light outages
- ii. Antenna Towers
  - a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
    - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
- iii. Overhead Wires
  - a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
  - b. These wires and lines may or may not be lighted
  - c. Be extremely vigilant on takeoff and landing
- iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
  - a. Ensure proper clearance between the aircraft and obstacle
    - If unsure of clearance, stop until you're sure it is safe to pass
- v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.
   i. Be alert for anyone/anything that may cause a hazard
      a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
         - Be cautious
         - Reject the takeoff or delay takeoff, if required
      b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
         - It may be necessary to reject a takeoff in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering

A. Low Altitude Maneuvering
   i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
         - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
   ii. Be aware of, and avoid obstructions on and around the airfield
      a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
      b. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin
   i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
      a. Airspeed
         - Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
         - If you get any indication of a stall at low level, recover from the stall and climb to a safe altitude
            a Max, Relax, Roll is a common memory aid for stall recovery
               1. Apply max power
               2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
               3. And roll wings level
   ii. Spin
      a. A spin is a result of a stall + yaw
         - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
      b. Prevention
         - Maintain coordination
         - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
         - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
    d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual
- C. 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. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
        - b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    - iii. Recommendations:
        - a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
        - b. Know and fly above minimum published safe altitudes.
            - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
        - c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
        - d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
        - e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
        - 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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

- A. Distractions
    - i. In the traffic pattern and during the climb to altitude, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and transitioning to the en route structure
    - ii. At a controlled field, listen to ATC's instructions
        - a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
    - iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
    - iv. Fly first!
        - a. Aviate, Navigate, Communicate
    - v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
    - vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
        - a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in and around the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground or in the air
    i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    ii. Maintain situational awareness
        a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
    i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
        a. No one responsibility should take your full attention full more than a short period
            - Continually move between tasks to ensure everything is being taken care of
        b. Safety is your number one priority
            - Aviate, Navigate, Communicate
    ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        a. Checklists are extremely helpful in properly managing tasks
    iii. Recognize when you are getting behind the aircraft, 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
        c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Verify assigned/correct runway.
4. Ascertain wind direction with or without visible wind direction indicators.
5. Position the flight controls for the existing wind conditions.
6. Clear the area, maintain necessary flight control inputs, taxi into takeoff position and align the airplane on the runway centerline without stopping, while advancing the throttle smoothly to takeoff power.
7. Confirm takeoff power and proper engine and flight instrument indications prior to rotation.
8. Establish and maintain a pitch attitude that will transfer the weight of the airplane from the wheels to the wings as rapidly as possible.
9. Lift off at the lowest possible airspeed and remain in ground effect while accelerating to V_X or V_Y, as appropriate.
10. Establish a pitch attitude for V_X or V_Y, as appropriate, and maintain selected airspeed +10/-5 knots during the climb.
11. Configure the aircraft after a positive rate of climb has been verified or in accordance with aircraft manufacturer's guidance.
12. Maintain V_X or V_Y, as appropriate, +10/-5 knots to a safe maneuvering altitude.
13. Maintain directional control and proper wind drift correction throughout takeoff and climb.
14. Comply with noise abatement procedures.

IV.D. Soft-Field Approach and Landing

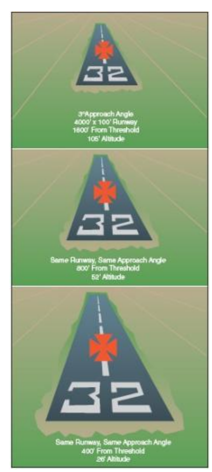
References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Stabilized Approach

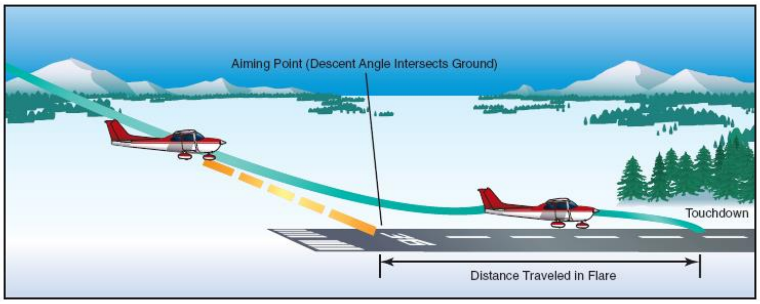
A. A Stabilized Approach
   i. A stabilized approach is one in which the pilot establishes and maintains a constant angle glidepath towards a predetermined point on the landing runway.
      a. A stabilized approach is a safe approach
      b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
      c. Adjust Pitch for airspeed and Power for altitude to maintain speed and glidepath
         - Control is maintained this way because at the slow approach speeds we are flying on the backside of the power curve, or the region of reverse command
            a *If this is not the case for your aircraft, don't do this
   ii. Controlling Descent
      a. Adjust power and pitch as necessary to maintain a stabilized approach and glide slope
         - Region of Reverse Command
            a Below LD_{MAX}
            b Use pitch for airspeed and power for altitude
               1. Pitching up decreases airspeed and vice versa
               2. Increasing power decreases your rate of descent and vice versa
            c Trim the control forces to maintain airspeed
      b. A change in any of the variables requires a coordinated change in the other controllable variables
         - EX: Why do we never try to stretch the gliding distance with back pressure alone?
            a If the Pitch attitude is raised too high without increasing power this will cause the airplane to settle rapidly, short of the desired landing spot
               1. The gliding distance is shortened if power is not increased simultaneously
         - Proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
            a If the approach is too high, lower the nose and reduce power
            b If the approach is too low, add power and raise the nose
            c Stay on airspeed



   iii. The Angle of Descent
      a. Aiming Points
         - The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
         - Select a point in front of the point of intended touchdown
            a Approximately 400 to 500' in front of touchdown to allow for the airplane's float
               1. This is equal to 2 to 2½ stripes prior to your intended touchdown point

        2. This point will vary based on the aircraft, configuration, weight, and wind conditions.
- Keep the aiming point steady on the wind screen
    a To a pilot moving straight ahead toward an object, the aiming point appears to be stationary, it does not move.
    b If the point begins to move up on the windscreen the airplane is getting too low
        1. Add power and raise the nose (maintain airspeed – the same airspeed with a higher power setting will result in a slower descent or climb)
    c If the point begins to move down on the windscreen the airplane is getting too high
        1. Reduce power and lower the nose (maintain airspeed – the same airspeed with a lower power setting will result in a steeper descent)
    d Small, active corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway
    e Airspeed remains constant throughout the approach

b. The Runway Image
- Too High
    a The runway will elongate and become narrower
        1. Overhead view of the runway
- Too Low
    a The runway will shorten and become wider
        1. Flat view of the runway



- On Descent Path
    a The runway will be between overhead and flat
    b The runway shape remains the same but grows in size as we approach

iv. Objective of a Stabilized Approach
  a. To select an appropriate touchdown point on the runway, and adjust the glidepath as necessary to roundout at or above the aiming point, providing distance for the flare to touchdown at the landing point

B. Energy Management
  i. A stabilized approach is based on well executed energy management
    a. As mentioned above, during the approach to final you are in the region of reverse command; power controls your rate of descent and pitch controls your airspeed
    b. A normal approach is based on a 3-degree glidepath (this translates to 300’ per nautical mile). Therefore, you should be 300’ above the touchdown zone elevation one mile from touchdown, and 600’ two miles from touchdown
      - This should give you a general idea if you’re on or off glidepath during the approach (if you’re able to recognize your distance from the runway)
      - The ability to recognize a normal, 3-degree approach path comes with practice and experience. If possible, find ground reference points at your home airport to monitor your descent.
    c. Once configured for the approach, set the approximate pitch attitude and power setting for approach speed

- The more familiar you are with the approximate pitch and power settings, the easier it will be to manage your energy and maintain a stabilized approach
- Once the approximate pitch and power setting is established, trim the control forces and crosscheck the airspeed, altitude, and glidepath
- Make adjustments to establish yourself on a 3-degree glidepath while maintaining approach speed
  - a Increase power to decrease your rate of descent. A coordinated increase in pitch will be required to maintain approach speed
    1. Increased power without a change in pitch will increase airspeed
  - b Decrease power to increase your rate of descent. A coordinated decrease in pitch will be required to maintain approach speed
    1. Decreased power without a change in pitch will decrease airspeed
  - c The key to stabilized, well managed, approaches is coordinated inputs between pitch and power in order to maintain a 3-degree glidepath to your aiming point at approach speed

d. "Go ugly early"
- Make corrections early. Don't make a gradual correction to the glidepath or centerline of the runway, establishing yourself just prior to touchdown. This is unsafe.
  - a You should be established on glidepath and course by 300'.
    1. This is a technique, but set a personal minimum where you will initiate a go around if you are not stabilized - on glidepath, airspeed, and runway course
- If you realize you are off course (altitude or course), "go ugly early"
  - a Make the necessary correction to reestablish yourself on glidepath and course as early as possible
  - b The earlier you are stable, the safer the approach
    1. Of course, don't be overly aggressive with the aircraft at slow airspeeds near the ground.
  - c For example, if you roll out a quarter to a half mile off centerline don't make a slow adjustment back to centerline, arriving just before touchdown. As soon as you see the mistake, make the required corrections to get established and stabilized early
    1. Yes, the approach will look "ugly early" (you may have to make a considerable correction back to centerline) but it is far safer to be established early than not be stabilized close to the ground

2. Effects of Atmospheric Conditions, Including Wind, on Approach and Landing Performance

A. Density Altitude

i. Density altitude is pressure altitude adjusted for non-standard temperature

ii. Increased density altitude (lower pressure and/or higher temperature) increases the landing speed

a. The aircraft lands at the same indicated airspeed, but because of reduced density (which can be a result of a lower pressure and/or a higher temperature), the true airspeed is greater
- The higher the altitude, the higher the true airspeed (it takes a greater speed to create the same amount of lift in the thinner air at high altitude than the thicker air near sea level)

B. Wind

i. Approach

a. A headwind on approach decreases the aircraft's groundspeed. Because the aircraft is traveling at a slower speed, the rate of descent necessary to maintain a stable 3-degree path will need to be decreased as well

- It will take longer to travel the same distance as if there was no wind, therefore the rate at which the aircraft descends needs to be reduced

b. A tailwind on the other hand increases the groundspeed and because the aircraft is traveling at a higher-than-normal speed, the rate of descent to maintain a 3-degree path will need to be increased

ii. Landing

a. A headwind during landing helps to reduce the landing ground roll while a tailwind increases the ground roll
   - In both cases the aircraft touches down with the same indicated airspeed, but with a headwind, the aircraft touches down at a lower ground speed and therefore can stop sooner than an aircraft with a tailwind (higher groundspeed on touchdown)

3. Wind Correction Techniques

A. Crosswind Basics

i. Imagine a 20kt headwind, directly down the runway

a. On the downwind leg you're flying with a tailwind, and the groundspeed is 20 knots higher than true airspeed
   - The crosswind leg now has a significant crosswind and heading will have to be adjusted to maintain your track
   - On final, the aircraft will begin to slow as the crosswind turns into a headwind, slowing the aircraft 20 knots
     - a A strong headwind slows your groundspeed, therefore the stronger the headwind, the lower your rate of descent to reach the runway
       1. The opposite applies, if you had a strong tailwind, you would need to descend faster since you are traveling faster than if you had zero wind or a headwind
   - Headwind on Approach = Slower descent rate (since you're traveling slower)

ii. Crosswind Basics in the Pattern

a. Adjust each leg to maintain a rectangle track – turn the aircraft into the wind to maintain the traffic pattern

b. Crosswinds on the runway result in overshooting or undershooting winds in relation to your turn to final
   - Imagine you are landing on runway 36 and have a wind from 060 degrees (a crosswind from the right on landing) this will result in an undershooting wind during the turn to final in left traffic and an overshooting wind in right traffic
     - a What this means is that using a normal amount of bank, as you make the turn to final the crosswind will either prevent you from reaching the runway centerline (undershooting) or push you past the runway centerline (overshooting)
     - b An undershooting wind will require less bank to align with the runway centerline and an overshooting wind will require more bank
       1. Always stay coordinated in your turns
   - Basic Rule: On downwind, if the wind is blowing you away from the runway, you have an undershooting wind. If the wind is blowing you toward the runway, you have an overshooting wind. Adjust as necessary.

B. Approach and Landing

i. The principal effect of wind on landing distance is to change the groundspeed at which the aircraft touches down

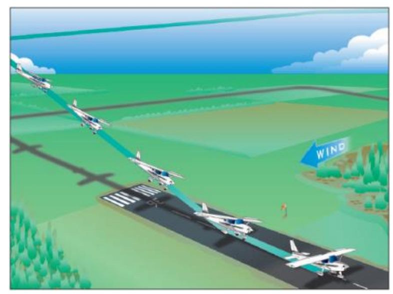
a. A headwind decreases the groundspeed at which the aircraft touches down, thus decreasing the landing roll

b. A tailwind increases the groundspeed at which the aircraft touches down, thus increasing the landing roll

ii. Crosswind Corrections

- a. Landing which must be made while the wind is blowing across rather that parallel to the landing direction
- b. The same basic principles apply to a crosswind and normal approach and landing
- c. Two methods of accomplishing a crosswind approach and landing
  - Crab Method
    - a Easier but requires a high degree of judgment and timing in removing the crab right before touchdown
    - b Not recommended
  - Sideslip (wing-low) Method
    - a Recommended

- d. Final Approach
  - Sideslip (Wing-Low)
    - a Align the airplane's heading with the centerline of the runway, noting the rate and direction of drift
    - b Promptly apply drift correction
      1. Lower the upwind wing
         - a. Amount of lowering depends on the drift
         - b. When the wing is lowered, the airplane will turn in that direction, so simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane in aligned with the runway
      2. The airplane will be side-slipping into the wind just enough so that the flight path and ground track are aligned with the runway
      3. Changes in the crosswind are corrected for accordingly



    - c Strong Crosswind
      1. In the case that it is not possible to maintain the centerline, the wind is too strong to safely land on the particular runway
         - a. In this case, there is insufficient rudder to maintain a heading with the required bank application
         - b. The landing should be made on a more favorable runway
    - d Maintain a stabilized approach
      1. Same as normal, except with the added side slip
      2. Because you are in a slip, drag is increased, more power will be necessary to maintain a given descent rate
- e. Roundout
  - Generally made like a normal landing approach, but the crosswind correction is continued as necessary to prevent drifting
    - a Don't level the wings
      1. This will result in drifting, which results in side loading the gear
  - Gradually increase the deflection of the elevators and rudder to maintain drift correction as the airplane slows
    - a The controls become less and less effective as airspeed is decreased
- f. Touchdown

- The touchdown should be made on the upwind main wheel first
    - a Maintaining crosswind correction to prevent drift
- As the momentum decreases, the weight of the airplane will cause the downwind main wheel to gradually settle onto the runway, then the nosewheel
    - a Remember to hold the nosewheel off the ground as long as possible in a soft-field landing
    - b Back pressure on the elevator will need to be increased as the controls become less effective due to decreasing airflow as the aircraft slows

g. After Landing Roll
- Maintain directional control with rudders
    - a With a greater profile behind the main wheels, the airplane will tend to weathervane into the wind
- Maintain crosswind control with ailerons
    - a Full aileron into the wind
        1. Keeps the upwind wing from rising
    - b As the speed decreases, increasing aileron is going to be necessary
- Maintain back pressure on the elevator to keep weight off the nosewheel
    - a Just as crosswind controls need to be increased as airspeed decreases, back pressure needs to be increased as the airspeed (and airflow over the control surfaces) decreases to keep a portion of the weight off the nosewheel and prevent getting stuck or worse, cart wheeling
    - b Don't be overly aggressive and strike the tail, adjust back pressure smoothly and appropriately as the aircraft slows

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

A. Pilot Capability

i. Not only should a pilot have personal weather minimums, but also runway minimums

a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level

b. Set a maximum crosswind limitation based on your abilities and comfort/safety level

c. These limitations may vary based on whether the runway is wet or dry or other factors

d. Be very competent with soft-field procedures prior to attempting them on your own

B. Aircraft Performance and Limitations and the Available Distance

i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual

a. Do not attempt to takeoff or land from a runway that is not supported by the landing data

b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe approach and landing

- Take into account the runway distance available as well as potential obstacles on the approach or in the case of a go around

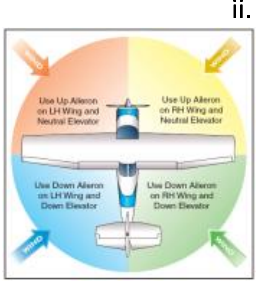
ii. Do not exceed any flight limitations – follow the flight manual
iii. Calculate landing distance based on the current atmospheric conditions using the manufacturer's landing distance tables
   a. Using METAR and TAF information (depending on when you intend to land) obtain landing distance with the landing distance charts in the flight manual
   b. The landing distance should be compared to the runway available
   c. Landing Distance will vary based on factors such as weight, density altitude, runway surface (very important in this case) and gradient, wind conditions, etc.
iv. Factors affecting Landing Distance
   a. Weight
      - Higher weights increase landing distance
   b. Wind
      - Increased Headwinds decrease landing distance
   c. Pressure/Density Altitude
      - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases landing distance
   d. Runway Slope and Condition
      - An inclined runway will decrease landing distance
      - Different types of runways can affect the landing distance
         a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual

C. The most favorable runway for landing meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
   i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
      a. This runway may be more favorable because it is aligned with your arrival direction, it may be a shorter taxi, it may be a longer runway, or it may provide a safer approach or climb out in the case of a go around
         - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

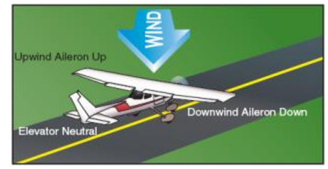
2. Crosswind

A. While usually preferable to land directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind
   i. See above for information on how to handle crosswinds safely
      a. The main idea is to use the ailerons to keep the aircraft centered on the runway and use the rudder to keep the longitudinal axis of the aircraft lined up with the centerline of the runway. This is to keep the aircraft on the runway and prevent damaging the gear

B. Crosswinds and Taxiing
   i. Taxiing with a tailwind
      a. Usually will require less engine power after the initial ground roll is begun
      b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally
   ii. Taxiing with a quartering headwind



a. Ailerons are turned into the headwind and the elevator is held neutral
b. 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
c. Also, the downwind aileron will be DOWN
   - A small amount of lift/drag is put on this wing keeping the upwind wing down



iii. Taxiing with a Quartering Tailwind
a. Ailerons are turned with the wind and the elevator is DOWN
   - Dive with the Wind
   - This reduces the tendency of the wind to nose the plane over
   - The upwind aileron is DOWN in this case (opposite of a head wind)

iv. These corrections minimize weathervaning and provide easier steering
v. Always know the direction of the wind in relation to the airplane
a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Maximum Demonstrated Crosswind Component
i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft
a. Prior to landing use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
   - If this exceeds the maximum demonstrated crosswind component, landing is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used
b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?
i. Unexpected change in wind direction and/or wind speed
ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?
i. It is often associated with thunderstorms
a. Microbursts
   - These can be extremely dangerous
ii. Inversion layer
a. Sometimes an inversion layer will result in a wind shift during descent

C. Dealing with it
i. Avoid It!
a. DO NOT FLY if there is potential for wind shear
b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
c. LLWAS (Low Level Wind Shear Alerting System)
   - Most major airports have an LLWAS
   - If available, it can warn of impending wind shear
   - PIREPS can be very informational
     a Direct reports from other pilots who experienced the wind shear

ii. Approach into Wind Shear
    a. If an option, divert to an airport with favorable weather conditions, otherwise,
        - Use more power
        - Maintain a Faster approach airspeed
            a Add ½ the gust factor to the approach speed
        - Stay as high as feasible until necessary to descend
        - Go Around at the first sign of a change in airspeed or unexpected pitch change
            a Important to get FULL power and get the aircraft into a max performance climb

4. Tailwind

A. A tailwind increases the runway required for landing
    i. Always verify the wind conditions and landing performance obtained are compatible with the runway of intended use

B. The flight manual will publish a maximum tailwind for landing, do not exceed this limit

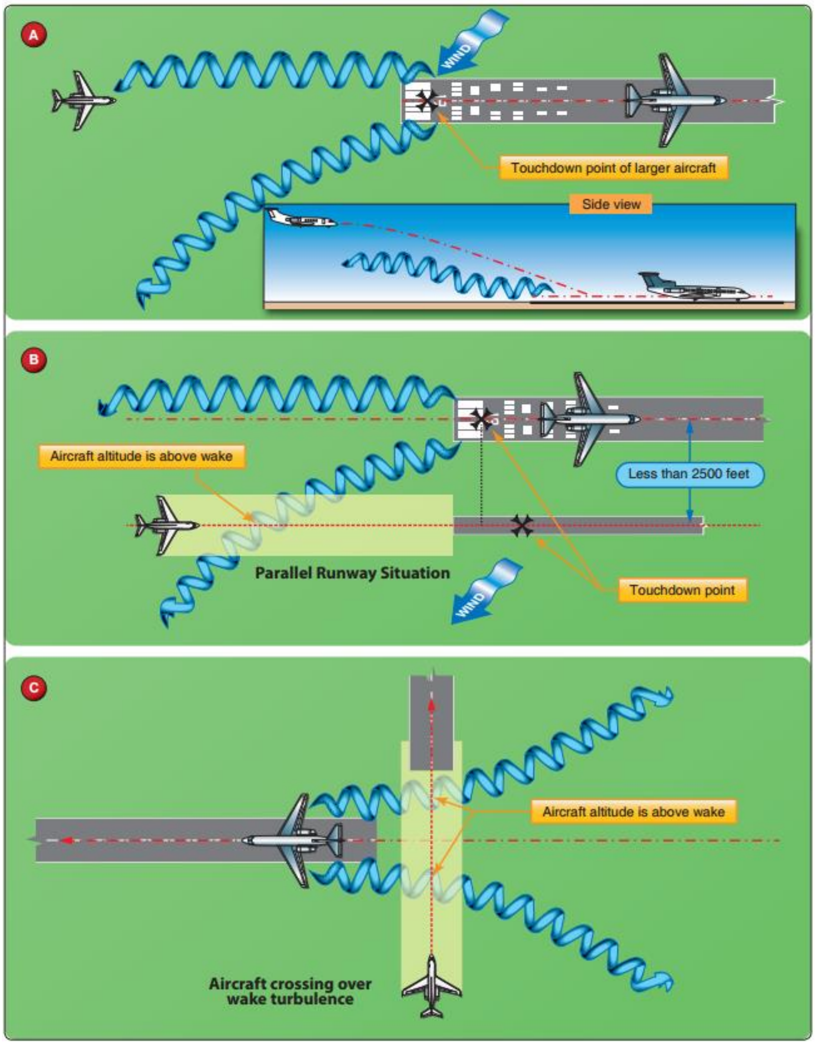
C. Use the performance charts to verify takeoff performance with the projected winds

5. Wake Turbulence

A. All aircraft generate wake turbulence during flight.
    i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
    ii. The vortices from larger aircraft pose problems to aircraft encountering them
        a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft

B. Wake Turbulence Recognition in the Terminal Area
    i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
    ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
        a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft

C. Wake Turbulence Resolution
    i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
        a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
        b. Crossing runways – cross above the larger jet's flight path
    ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. Runway Surface/Condition

A. Runway conditions affect takeoff performance
   i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces

B. Surface
   i. Runway surfaces vary widely. The runway surface may be concrete, asphalt, gravel, dirt, or grass
      a. The runway surface for a particular airport can be found in the Chart Supplement
      b. Any surface that is not hard (grass, dirt, etc.) decreases the ground roll during landing
         - Tires sink into soft runways and the tires do not roll smoothly over the surface
   ii. Braking effectiveness is another consideration when dealing with different runway types
      a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft
   iii. The gradient of the runway can also have an effect on the landing ground roll
      a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3’ for every 100’ of runway length
      b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
      c. An upsloping runway assists deceleration and decreases the takeoff roll

C. Condition

i. Braking effectiveness comes into play for different runway conditions
   a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to stop the aircraft
      - Water decreases the friction between the tires and the ground, reducing braking effectiveness
      - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway's surface – braking and directional control are almost nil.
         a Grooved runways help to reduce hydroplaning
         b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
      - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
         a Use aerodynamic braking to its fullest advantage

D. Length
   i. Runway length obviously needs to accommodate the landing distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
   ii. Never attempt a landing on a runway that is not supported by the landing data
   iii. Ensure that runways are adequate in length for landing when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for:

A. Rejected Landing and Go-Around
   i. Go Arounds Are Free
      a. If you're ever in doubt, go around
      b. Maintain a stabilized approach
         - Stable means on airspeed, glidepath, and runway centerline
            a *Momentary* deviations from speed, glidepath and centerline are acceptable
         - Set limits for airspeed/altitude requirements and an altitude at which if you are outside any of these limits you will go around – no questions asked
            a For example, ±5 knots and within 50' of altitude within a half mile of the runway (150' AGL)
               1. Assuming a 3-degree glidepath, you should be 300' AGL one mile out and 600' AGL 2 miles out, etc. Unless you have ground references at these points, recognizing this will come with experience
               2. If you are outside of these tolerances, the approach is unstable and it is time to go around
   ii. Delaying the go-around often stems from two sources:
      a. Landing expectancy
         - The set anticipatory belief that conditions are not as threatening as they are and that the approach will surely end with a safe landing
      b. Pride
         - The mistaken belief that a go around is an admission of failure
      c. Understand these conditions and don't let them influence your decision to go around

B. Land and Hold Short Operations (LAHSO)
   i. LAHSO operations may be in effect when simultaneous operations are being conducted on intersecting runways

a. The idea is to allow simultaneous takeoffs and landings on intersecting runways
b. ATC will clear an aircraft to land and hold short (stop before crossing the intersecting runway) to allow use of the intersecting runway
    - Runway holding position signs and markings are installed on runways prior to the intersection at which you need to hold short

ii. As Pilot in Command, you have the final authority to accept of decline any LAHSO clearance
a. You are never required to accept the clearance, if you are uncomfortable simply reply "unable" to ATC
b. If you accept a LAHSO clearance you must comply so that no portion of the aircraft extends beyond the hold markings

iii. The holding position sign has a white inscription with a black border around the numbers on a red background and is installed adjacent to the holding position markings

iv. 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. Know what signs and markings are at the LAHSO point
e. LAHSO are not authorized for student pilots who are performing a solo flight
f. At many airports, air carriers are not authorized LAHSO if the other aircraft is general aviation
g. Generally, LAHSO are not authorized at night
h. LAHSO are not authorized on wet runways

8. Collision Hazards

A. Aircraft

i. Operation Lights On
a. A voluntary FAA safety program to enhance the see and avoid concept
b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
    - If they are different categories:
        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
    - Each pilot shall alter course to the right

d. Overtaking
    - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing

- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
    - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
    - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary
   c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

        a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
        b. Become familiar with any obstacles on the departure path
        c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
        d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
        e. NOTAMs are issued on lighted structures experiencing light outages
    ii. Antenna Towers
        a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
            - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing
    iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
        a. Ensure proper clearance between the aircraft and obstacle
            - If unsure of clearance, stop until you're sure it is safe to pass
    v. If necessary, radio ground to inform them of your intentions or ask for assistance
D. Vehicles, Persons, Wildlife, etc.
    i. Be alert for anyone/anything that may cause a hazard
        a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
            - Be cautious
            - Initiate a go-around, if required
        b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
            - It may be necessary to go-around in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering

A. Low Altitude Maneuvering
    i. A small problem at high altitude can quickly become a big problem at a low altitude
        a. There is considerably less time to handle any issues at a low altitude
        b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
            - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
    ii. Be aware of, and avoid obstructions on and around the airfield
        a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
        b. Plan ahead to avoid obstacles
B. Low Altitude Stall/Spin
    i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.

a. Airspeed
    - Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach.
        - a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
    - If you get any indication of a stall at low level, recover from the stall and go around
        - a Max, Relax, Roll is a common memory aid for stall recovery
            1. Apply max power
            2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
            3. And roll wings level

b. Cross Controlled Stall
    - Here's a situation that will lead to a cross-controlled condition in the pattern:
        - a In a descent, the pilot starts the left turn from base to final late, additionally there's an overshooting wind pushing the aircraft past the runway centerline and potentially into the final approach of a parallel runway
        - b In order to attempt to fix the problem, the pilot rolls to 30º of bank, knowing that is the limit for safe bank in the pattern, but 30º of bank is not enough to line aircraft up with the centerline, an overshoot is inevitable
            1. In order to correct, and avoid the parallel runway's final approach area, the pilot adds left rudder (trying to force the airplane around the corner and avoid the overshoot), while maintaining 30º of bank
                a. The left rudder pushes the nose around, and also increases lift on the right wing (the yaw swings the right wing around, moving it faster than the left, increasing lift)
                b. As lift increases on the right wing, the aircraft rolls left, the pilot applies right aileron to maintain 30º of bank
                    i. The aircraft is now in an uncoordinated cross-controlled situation - Left rudder and right aileron
        - c This can quickly lead to a very dangerous cross-controlled stall. One in which the aircraft may roll over (almost, if not fully inverted). The natural reaction of rolling in the opposite direction only intensifies the stall. This is likely unrecoverable at low altitudes. Maintain coordination!

ii. Spin

a. A spin is a result of a stall + yaw
    - The primary cause of a spin is stalling the aircraft in an uncoordinated turn

b. Prevention
    - Maintain coordination
    - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
    - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again

d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. The majority of CFIT incidents occur during final approach and landing
      b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
      c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
   iii. Recommendations:
      a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
      b. Know and fly above minimum published safe altitudes.
         - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
      c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
      d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
      e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
      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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. In the descent, approach, traffic pattern, and landing, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.
   ii. At a controlled field, listen to ATC's instructions
      a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
   iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
   iv. Fly first!
      a. Aviate, Navigate, Communicate
   v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
   vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
      a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air

i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
ii. There is no place for distractions in the traffic pattern and in the runway environment
iii. Maintain situational awareness
    a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
   i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
      b. Safety is your number one priority
         - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
      a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, and find a way to catch up
      a. If more time is needed, go around, find somewhere to hold/circle, or slow down
      b. Ask for assistance, if possible
      c. Don't give up or overstress yourself. Take it one step at a time.

These topics were removed in the latest ACS, but they seem pertinent and important, so here they are:

1. Risks associated with Soft Field Landings

A. Losing Elevator Control
   i. Elevator effectiveness is dependent on airflow; therefore, you must keep moving in order to maintain elevator control during taxi
   ii. Losing elevator control results in increased weight on the nosewheel, which can result in taxi hazards such as getting stuck, or at high speeds the potential to lose control or even cartwheel

B. Sinking into the Soft Surface
   i. The aircraft may not be able to move if allowed to sink into the soft surface
      a. Maintain back pressure on the yoke/stick when taxiing to keep weight off the nosewheel
      b. Do not stop! (unless you have to – for example: don't hit another aircraft)
         - The idea is to start the taxi and takeoff without stopping the aircraft in order to prevent sinking
   ii. Be very cautious trying to get the aircraft moving when stuck
      a. A lot of power may be necessary to get moving
         - This may be dangerous to you as well as anyone around the aircraft (especially behind you since you'll be blowing debris all over)
         - Once the aircraft breaks free you may shoot forward due to the high-power setting
      b. The safest choice may be to shut down and get it towed or pull/dig the aircraft out

C. Striking the Prop (from moving too slow)
   i. Maintain back pressure when taxiing – keep the weight off the nose
   ii. Due to the potential bumpy, holey taxi surface it is very possible to strike the prop while taxiing too slowly

a. This does not mean to taxi really fast. Taxi at a safe, controlled speed and keep the weight off the nose wheel
b. Avoid holes or uneven terrain if possible, and safe

2. Hazards of other than Hard Surfaced Runway

A. Firm Touchdown
  i. A firm touchdown can result in the aircraft sticking in the soft surface
    a. This can result the aircraft tumbling or cartwheeling if it sticks hard enough

B. High Speed Approach and Touchdown
  i. Approach
    a. The use of higher speeds may result in excessive float in ground effect, and floating makes a smooth, controlled touchdown even more difficult
  ii. Touchdown
    a. During the landing, the aircraft is held 1-2' off the surface, in ground effect, as long as possible to allow a gradual dissipation of speed and allow the wheels to touch down gently at min speed
      - This is done to minimize nose over forces that affect the aircraft at the moment of touchdown and minimize the stress on the gear and potential damage to the wings and flaps
    b. High speed touchdowns increase the nose forward tendency, and create larger stresses on the gear which could result in damage. Additionally, the high speeds result in faster moving debris on touchdown which may hit the flaps and wings causing damage

3. Emergency Procedures during Approach and Landing

A. General
  i. Depending on the emergency situation the choice will have to be made as to whether go around to handle the emergency airborne or continue to land.
    a. Go Around
      - There are situations that can be better handled airborne than on the ground
        a If you get an emergency close to the ground (that doesn't affect the aircraft's ability to fly) and could create a hazard during landing, whether as a distraction or in relation to the safety of the aircraft it may be better to go around
        b For example: landing gear problems. Go around and attempt to solve the problem airborne
    b. Continue to Land
      - There are many situations that can be better handled by continuing the landing instead of going around to attempt to fix the problem
        a If you experience an emergency that can affect the airplane's ability to fly, it is likely best to continue to land the aircraft
        b For example: if the engine starts running rough at 500', do not attempt to go around as it may exacerbate the problem and quickly lead to an emergency landing. Fires are also a great reason to land the aircraft immediately.
  ii. This is a very basic, surface level discussion as to whether go around or continue to land. These emergencies are aircraft and situation dependent, there may not necessarily be a correct procedure (go around or land), and depends on the pilot in commands discretion
    a. Hindsight is always 20/20. Take time to review and learn from NTSB accident reports, and consider how you would handle different situations.

B. Engine Failure
  i. In the case of an engine failure, the aircraft pitch needs to be immediately adjusted to maintain the best glide speed

a. Know the approximate pitch attitude, establish it and trim the aircraft to maintain the speed. This will provide the greatest glide distance based on your altitude
b. A normal landing pitch attitude is often too high to maintain the power off best glide speed
    - Airspeed will decrease, and your rate of descent will increase, reducing your glide distance
    - Lower the nose as necessary

ii. Decide where you will attempt to land the aircraft
a. If you can make the airport, of course, continue to land there
b. If not, find the most suitable area

iii. If time allows, execute the emergency checklist
a. Divide attention between flying the aircraft (maintaining speed, course, and descent to the planned landing site) and accomplishing the checklist
b. It is beneficial to have the major portions of this checklist memorized
    - Time is of the essence, and having the first essential steps to reestablish engine power memorized could be the difference between a powered landing on the runway and an off airport, power off landing

iv. Adjust your descent to reach the landing zone
    - Use airspeed, flaps, and slips if necessary to increase your rate of descent to make your landing zone

C. Landing

i. Remember you are making a soft-field landing without power. Doing everything as normal, but perform a soft-field landing, touching down gently, keeping the nose wheel off the ground, etc.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Ensure the aircraft is aligned with the correct/assigned runway
4. Scan the landing runway and adjoining area for traffic and obstructions
5. Consider the wind conditions, landing surface, obstructions, and select a suitable touchdown point.
6. Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
7. Maintain manufacturer's published airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots, with wind gust factor applied.
8. Maintain crosswind correction and directional control throughout the approach and landing sequence.
9. Make smooth, timely, and correct control inputs during round out and touchdown and, for tricycle gear airplanes, keep the nose wheel off the surface until loss of elevator effectiveness.
10. Touch down at a proper pitch attitude, with minimum sink rate, no side drift, and with the airplane's longitudinal axis aligned with the centerline of the runway.
11. Maintain elevator as recommended by manufacturer during rollout and exit the "soft" area at a speed that would preclude sinking into the surface.
12. Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
13. Maintain proper position of the flight controls and sufficient speed to taxi on the soft surface.

IV.E. Short-Field Takeoff and Maximum Performance Climb

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Effects of Atmospheric Conditions, Including Wind, on Takeoff and Climb Performance**
   A. Atmospheric conditions greatly affect takeoff distance
      i. Pressure Altitude
         a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
            - $1{,}000(29.92 - \mathrm{Alt}) + \mathrm{Elev}$
         b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
            - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
               a Therefore, aircraft takeoff and climb performance will improve with higher air pressure (shorter takeoff distance, and increased climb performance)
            - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather
      ii. Density Altitude/Temperature
         a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
            - $120(°\mathrm{C} - 15°\mathrm{C}) + \mathrm{PA}$ (this is an approximation)
         b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
            - Lower temperatures (the air is more compressed) result in better performance
            - Higher temperatures (the air is less compressed) result in poorer performance
            - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
               a Lower temperatures result in better performance (shorter takeoff run and increased climb performance)
               b Overall, high pressure, cold days result in the best takeoff and climb performance
      iii. Humidity
         a. Although not directly accounted for on the performance charts, humidity decreases performance
   B. Wind Conditions and Effects
      i. Wind and Takeoff Distance
         a. The effect of wind on takeoff distance is large, and proper consideration must be given when predicting takeoff distance
         b. A headwind allows the aircraft to reach lift-off speed at a lower groundspeed
            - There is wind moving over the wings while the aircraft is standing still, thus the aircraft can leave the ground at a lower ground speed
         c. A tailwind requires the aircraft reach a higher groundspeed to reach lift off speed
            - If there is a 10-knot tailwind, the aircraft has to accelerate to 10 knots before the speed of the air over the wings reaches 0 knots
      ii. Headwinds also increase the aircraft's ability to climb

a. Greater airflow over the wings results in increased lift and therefore increased climb performance
b. A headwind also decreases the aircraft's groundspeed allowing the aircraft to climb to a given altitude in a shorter distance

2. V_X and V_Y

A. V_X: The speed at which the aircraft obtains the highest altitude in a given horizontal distance. The best Angle of Climb (AOC) speed normally increases slightly with altitude.
   i. An example of when max AOC is used, is when taking off from a short airfield surrounded by high obstacles (trees, power lines, etc.)
   ii. V_X occurs at the airspeed and angle of attack combination which allows for the maximum excess thrust
B. V_Y: The speed at which the aircraft obtains the maximum increase in altitude per unit of time. The best Rate of Climb speed normally decreases slightly with altitude.
   i. V_Y depends on excess power and occurs at the airspeed and angle of attack combination that produces the most excess power.
      a. Since climbing is work, and power is the rate of performing work, a pilot can increase the climb rate by using any power not used to maintain level flight
C. In the case of a short-field takeoff the intention is often to clear some sort of obstacle at or near the departure end of the runway with a maximum performance climb
   i. Always be well aware of the obstacle height, both AGL and MSL
   ii. Climb at V_X until positively cleared of the obstacle(s)
      a. Once definitively above the obstacle, lower the nose to accelerate to V_Y and continue as though it's a normal takeoff
         - Definitively clear of the obstacle can mean different things for different people. This is another place you can set a personal minimum. For example, as a personal safety buffer you may want to continue your climb until 250' above the highest obstacle, only then accelerating to V_Y and continuing as normal

3. Appropriate Aircraft Configuration

A. The aircraft should be configured for a short-field takeoff and maximum performance climb per the flight manual
   i. In most aircraft this is the same as a normal takeoff. Flaps are used to increase lift and provide for increased climb rates at slower speeds
   ii. If the aircraft is not configured per the flight manual the performance data from the performance charts is negated
B. The idea behind a short field takeoff is to liftoff in the shortest ground roll and maintain the steepest angle of climb until clear of any obstacles
   i. Some prefer to hold the brakes until reaching maximum engine rpm and then begin the takeoff roll. According to the Airplane Flying Handbook, it has not been established that his procedure will result in a shorter takeoff run in all light single-engine aircraft.
   ii. Whichever way the flight manual recommends you perform a short-field takeoff, the power should be applied smoothly and continuously – without hesitation – to accelerate the aircraft as quickly as possible
   iii. The aircraft is rotated near the best angle of climb speed (V_X), and pitched to maintain V_X until clear of any obstacles, or if no obstacles are involved, until an altitude of at least 50' above the takeoff surface (of course, use the rotation speed as prescribed in the flight manual)
      a. Since the aircraft will accelerate more rapidly after lift-off, additional back elevator pressure becomes necessary to hold a constant airspeed

    b. In some aircraft, a deviation of 5 knots from the recommended speed will result in a significant reduction in climb performance, therefore precise control of airspeed is very important

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind**
    A. Pilot Capability
        i. Not only should a pilot have personal weather minimums, but also runway minimums
            a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
            b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
            c. These limitations may vary based on whether the runway is wet or dry or other factors
            d. Be very competent with short-field procedures prior to attempting them on your own
    B. Aircraft Performance and Limitations and the Available Distance
        i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
            a. Do not attempt to takeoff or land from a runway that is not supported by the landing data
            b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe takeoff and climb
                - Take into account the runway distance available as well as potential obstacles on climb out
            c. Do not exceed any flight limitations – follow the flight manual
        ii. The minimum takeoff distance is obtained by taking off at some minimum safe speed for the current conditions that allows sufficient margin above stall and provides satisfactory control and initial rate of climb
            a. Generally, the lift-off speed is some fixed percentage of the stall speed or minimum control speed
            b. In the case of a short-field takeoff, the aircraft is rotated when approaching the best angle of climb speed (V_X), and pitched to maintain that speed
                - Of course, always use the flight manual prescribed rotation speed for the appropriate type of takeoff
                - Takeoff should also be started at the very beginning of the takeoff area
                    a Since it's a short runway, utilize everything you can
        iii. Calculate Takeoff Distance based on the current atmospheric conditions using the manufacturer's takeoff distance tables for a Short-Field Takeoff
            a. Using the local weather information (METAR, TAF, etc. depending on when you intend to takeoff) obtain takeoff distance with the performance charts in the flight manual
            b. The takeoff distance should be compared to the runway available
        iv. Factors affecting Takeoff Distance
            a. Weight
                - Higher weights increase takeoff distance
            b. Wind
                - Increased Headwinds decrease takeoff distance

- c. Pressure/Density Altitude
  - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases takeoff distance
- d. Runway Slope and Condition
  - An inclined runway will increase takeoff distance
  - Different types of runways can affect the takeoff distance
    - a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction to overcome on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual.

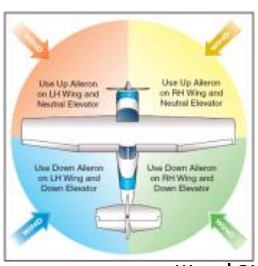
C. The most favorable runway for takeoff meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
- i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
  - a. This runway may be more favorable because it is aligned with your departure direction, it may be a shorter taxi, it may be longer, or it may provide a safer climb
    - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

D. Ensure you have the takeoff distance required based on the flight manual charts and current conditions
- i. Don't takeoff off if you don't have the required performance

2. Crosswind

A. While usually preferable to takeoff directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind

B. Crosswinds and Taxiing
- i. Taxiing with a tailwind
  - a. Usually will require less engine power after the initial ground roll is begun
  - b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally
- ii. Taxiing with a quartering headwind



  Ailerons are turned into the headwind and the elevator is held neutral

  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

  Also, the downwind aileron will be DOWN
  - A small amount of lift/drag is put on this wing keeping the upwind wing down
- iii. Taxiing with a Quartering Tailwind
  - a. Ailerons are turned with the wind and the elevator is DOWN
    - Dive with the Wind
    - This reduces the tendency of the wind to nose the plane over
    - The upwind aileron is DOWN in this case (opposite of a head wind)

- iv. These corrections minimize weathervaning and provide easier steering
- v. Always know the direction of the wind in relation to the airplane
  - a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Crosswinds and Takeoff
- i. Taxi onto the Runway
  - a. Before taxiing onto the runway adequately clear the area; do not taxi onto the runway if it is not safe

b. The airplane should be carefully aligned with the intended takeoff direction, and the nose wheel positioned straight, or centered

ii. If a crosswind is indicated (windsock, ATIS, other direction indicators) full aileron should be held into the crosswind as the roll is started
   a. This raises the aileron on the upwind wing to impose a downward force on the wing counteracting the lifting force of the crosswind and preventing the wing from raising
   b. With the aileron into the wind, the rudder should be used to keep the takeoff path straight
      - Rudder in the direction opposite of the aileron input is required to keep the takeoff path straight

iii. Gaining Speed
   a. As the forward speed is increased, the crosswind becomes more of a relative headwind and the air moving faster over the flight controls causes them to be more effective, therefore full aileron pressure into the wind should gradually be reduced
      - Some aileron pressure will need to be maintained – It doesn't all go away
         a Don't be mechanical in the use of aileron control, rather sense the need for varying aileron control input through feel for the plane and visual indications
         b Don't use excessive aileron input in the latter stage of the takeoff roll, this can result in a steep bank into the wind at lift-off (putting the wing near the runway surface)
            1. Slowly reduce aileron pressure as the crosswind becomes more of a relative headwind and the control surfaces become more effective

iv. Avoid an early lift-off resulting in side-skipping
   a. If the correction is not held properly, a skipping action may result
      - Indicated by a series of very small bounces
   b. Side-skipping imposes severe side stresses on the landing gear and could result in structural failure

v. Lift-Off
   a. In a significant crosswind, hold the main gear on the ground longer to ensure a smooth but definite takeoff
      - Leave the ground with more positive control and prevent side loading on the landing gear
   b. It is important that sufficient aileron is held into the wind so that immediately after liftoff the aircraft is side slipping into the wind to counteract drift
      - 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
         a This is acceptable and preferred to side skipping
   c. Once the plane leaves the ground drift correction needs to be maintained
      - Visually
         a The runway will begin to disappear as the nose pitches upward
         b Maintain the centerline as well as airplane pitch and bank with outside references and instrument indications
      - Instrument Indications
         a Pitch to maintain V_Y (or whatever speed required for the situation)
            1. Make small adjustments as necessary for airspeed

D. Maximum Demonstrated Crosswind Component
   i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft
      a. Prior to takeoff use a calculator to figure out the crosswind component based on the current winds and the intended runway of use

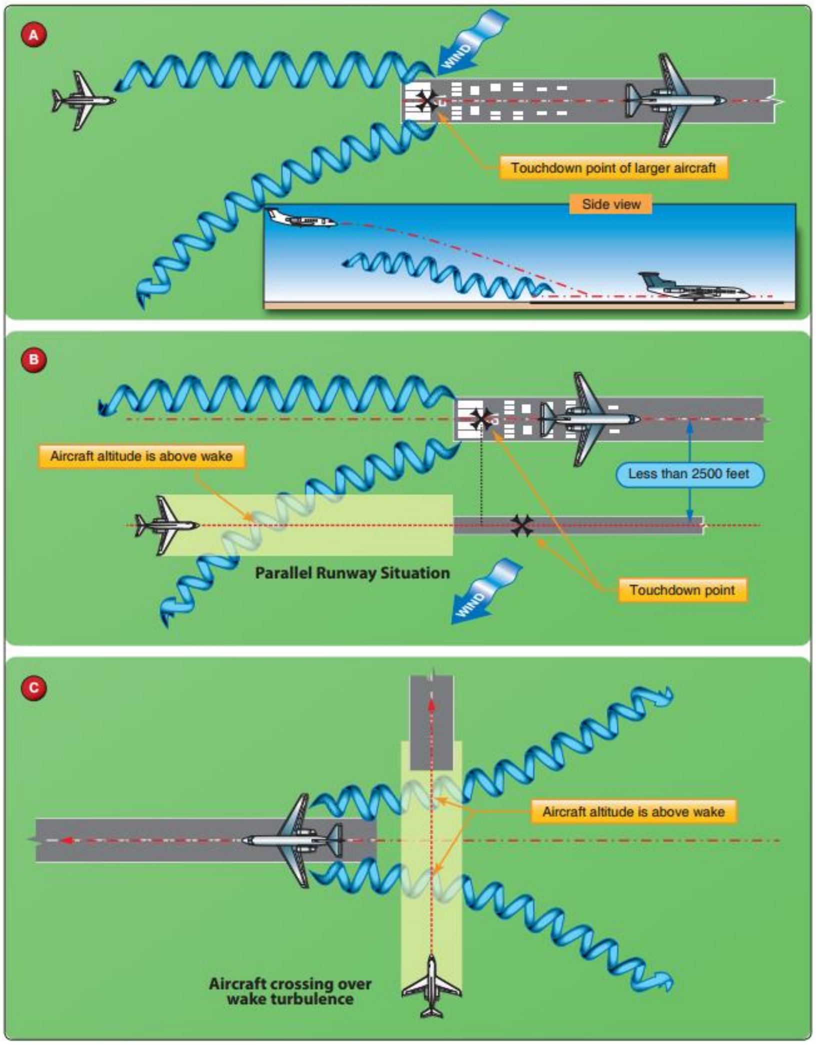
        - If this exceeds the maximum demonstrated crosswind component, takeoff is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used
    b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. **Wind Shear**
    A. What is it?
        i. Unexpected change in wind direction and/or wind speed
        ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft
    B. Where is it?
        i. It is often associated with thunderstorms
            a. Microbursts
                - These can be extremely dangerous
        ii. Inversion layer
            a. Sometimes an inversion layer will result in a wind shift during descent
    C. Dealing with it
        i. Avoid It!
            a. DO NOT FLY if there is potential for wind shear
            b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
            c. LLWAS (Low Level Wind Shear Alerting System)
                - Most major airports have an LLWAS
                - If available, it can warn of impending wind shear
                - PIREPS can be very informational
                    a Direct reports from other pilots who experienced the wind shear
        ii. Wind Shear after Takeoff
            a. If possible, land straight ahead on the remaining runway
            b. If not, increase to max power, and begin a maximum performance climb
                - Be aware that the aircraft may not fly, you may be forced to land

4. **Tailwind**
    A. A tailwind increases the runway required for takeoff
        i. Always verify the wind conditions and takeoff performance obtained are compatible with the runway of intended use
    B. The flight manual will publish a maximum tailwind for takeoff, do not exceed this limit
    C. Use the performance charts to verify takeoff performance with the projected winds

5. **Wake Turbulence**
    A. All aircraft generate wake turbulence during flight.
        i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
        ii. The vortices from larger aircraft pose problems to aircraft encountering them
            a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft
    B. Wake Turbulence Recognition in the Terminal Area
        i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
        ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
            a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft

C. Wake Turbulence Resolution
   i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
      a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
      b. Crossing runways – cross above the larger jet's flight path
   ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. Runway Surface/Condition
   A. Runway conditions affect takeoff performance
      i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces
   B. Surface
      i. Runway surfaces vary widely (concrete, asphalt, dirt, grass, etc.)
         a. The runway surface for a particular airport can be found in the Chart Supplement

   b. Any surface that is not hard (grass, dirt, etc.) increases the ground roll during takeoff
      - Tires can sink into soft runways and the tires do not roll smoothly over the surface
      - Use the soft field procedures to compensate for the runway surface since aircraft acceleration is reduced so much that adequate takeoff speed may not be attained if normal takeoff techniques were employed

ii. Braking effectiveness is another consideration when dealing with different runway types
   a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft

iii. The gradient of the runway can also have an effect on the takeoff ground roll
   a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3' for every 100' of runway length
   b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
   c. An upsloping runway impedes acceleration and increases the takeoff roll

C. Condition

i. Obstructions such as mud, snow, or standing water also reduce the aircraft's acceleration down the runway
   a. Dry runways provide the best acceleration

ii. Braking effectiveness also comes into play for different runway conditions
   a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to reject a takeoff
      - Water decreases the friction between the tires and the ground, reducing braking effectiveness
      - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway's surface – braking and directional control are almost nil.
         a Grooved runways help to reduce hydroplaning
         b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
      - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
         a Use aerodynamic braking to its fullest advantage

D. Length

i. Runway length obviously needs to accommodate the takeoff distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft

ii. Never attempt a takeoff on a runway that is not supported by the takeoff data

iii. Ensure that runways are adequate in length for takeoff acceleration and deceleration when less than ideal runway surfaces and/or runway conditions are being reported

iv. This is very important for short-field takeoffs – be very familiar and comfortable with the takeoff distance available and takeoff distance required

7. Abnormal Operations, to Include Planning for Rejected Takeoff and Engine Failure in Takeoff/Climb Phase of Flight

A. Always have a plan before starting the takeoff roll. Brief that plan

i. The Air Force and airlines will brief every departure. The brief reviews the standard procedures, expected procedures and actions, as well as intentions in the case of an emergency during takeoff
   a. Prior to rotate speed, plan to keep the aircraft on the ground (assuming the runway distance allows this)

b. Brief an altitude at and above which, you will turn around to return to the airport for landing (assuming this is possible on the short field – consider all obstacles)
c. Between the point at which you can no longer land on the remaining runway (a) and the point at which you have the altitude to return to the airport (b) you will have to land on the most suitable surface outside of the airport
    - Know what options you have

B. Rejected Takeoff
    i. Circumstances such as engine malfunctions, inadequate acceleration, runways incursion, ATC conflict, or any other emergency can result in a takeoff having to be rejected on the runway
        a. Inadequate Acceleration
            - Prior to takeoff, the pilot should have in mind a point along the runway at which the airplane should be airborne. If that point is reached and the airplane is not airborne, immediate action should be taken to reject the takeoff
            - Depending on the length of the short field runway, this may not be an option since there may not be sufficient runway to stop the aircraft
                a Be very familiar with the takeoff data (distance required) and the amount of runway available
                b Consider only using runways that will allow the pilot the opportunity to reject the takeoff up to rotation speed since it may not be possible to reject a takeoff near rotation speed on a short runway
        b. Rejected Takeoff Procedures
            - Follow the procedures as specified the manufacturer's flight manual
            - Generally, the pilot will reduce power to idle, and apply maximum braking while maintaining directional control
            - If it is required to shut down the engine due to a fire, or for any other reason, the mixture control should be brought to the idle cutoff position and the magnetos turned off. Follow the manufacturer's emergency checklist

C. Engine Failure
    i. Time is of the essence
        a. In most instances the pilot only has a few seconds after engine failure to decide what course of action to take and to execute those actions
        b. Unless prepared in advance to make the proper decision, there is an excellent chance that the pilot will make a poor decision or no decision at all
    ii. Procedures
        a. The first responsibility is to maintain aircraft control
        b. During the takeoff roll, reject the takeoff and stop straight ahead
            - Be familiar with the ground distance required to stop the aircraft. On a short field, there may not be sufficient distance to stop without hitting an obstacle or departing the runway
        c. During the takeoff climb
            - During the takeoff climb, the aircraft will have full power, a higher-than-normal pitch attitude (V_X) and right rudder
            - When the engine fails, the pilot must immediately lower the nose (to the best glide speed) to prevent a stall and/or spin, and release the right rudder since the turning tendencies have been removed
                a If the engine doesn't totally fail, some right rudder may be necessary to maintain coordination

- Once the pilot has control of the aircraft, establish a controlled glide toward a plausible landing area (preferably straight ahead)
- During climb, know at what altitude you can return to the field and what options you have other than the airfield
    - a This is especially important at a short field runway since there is likely an obstacle (or obstacles) that can pose a serious hazard

8. Collision Hazards

A. Aircraft

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
    - a A balloon has the right of way over any other category
    - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
    - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
    - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on

- Each pilot shall alter course to the right

d. Overtaking

- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing

- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
    - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
    - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:

- 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. Before Takeoff: Scan the runway and final approach for other traffic
   b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

v. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500’ AGL and particularly below 200’ AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb after takeoff and is especially important on a short runway which often includes an obstacle at the departure end
      b. Become familiar with any obstacles on the departure path
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200’ AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)

b. These wires and lines may or may not be lighted
c. Be extremely vigilant on takeoff and landing
iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
a. Ensure proper clearance between the aircraft and obstacle
- If unsure of clearance, stop until you're sure it is safe to pass
v. If necessary, radio ground to inform them of your intentions or ask for assistance
D. Vehicles, Persons, Wildlife, etc.
i. Be alert for anyone/anything that may cause a hazard
a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
- Be cautious
- Reject the takeoff or delay takeoff, if required
b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
- It may be necessary to reject a takeoff in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering/Stall/Spin
A. Low Altitude Maneuvering
i. A small problem at high altitude can quickly become a big problem at a low altitude
a. There is considerably less time to handle any issues at a low altitude
ii. Therefore, avoid distractions, maintain situational awareness, and fly precisely. Know the approximate pitch attitude to maintain V_X and V_Y
a. Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
- Establish the pitch attitude for V_X on liftoff and make small adjustments in order to stay as close as possible to this speed in order to provide the best climb performance
b. Be aware that you are climbing at speeds relatively close to stall
- A simple distraction could result in the aircraft pitching up a few degrees unnoticed and a potential stall near the ground
- Divide your attention as necessary, frequently verifying your airspeed and pitch attitude
  a Aviate, Navigate, Communicate. Flying the aircraft always comes first.
iii. Be aware of, and avoid obstructions on and around the airfield
a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
b. Plan ahead to avoid obstacles
B. Low Altitude Stall/Spin
i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
a. Airspeed
- Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
- If you get any indication of a stall at low level, recover from the stall and climb to a safe altitude
  a Max, Relax, Roll is a common memory aid for stall recovery
  1. Apply max power

        2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
        3. And roll wings level

ii. Spin
   a. A spin is a result of a stall + yaw
      - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
   b. Prevention
      - Maintain coordination
      - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
      - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
   d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
      b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
   iii. Recommendations:
      a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
      b. Know and fly above minimum published safe altitudes.
         - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
      c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
      d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
      e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
      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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. In the traffic pattern and during the climb to altitude, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and transitioning to the en route structure
ii. At a controlled field, listen to ATC's instructions
    a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
iv. Fly first!
    a. Aviate, Navigate, Communicate
v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in and around the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground or in the air
   i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   ii. Maintain situational awareness
       a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
   i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
       a. No one responsibility should take your full attention full more than a short period
          - Continually move between tasks to ensure everything is being taken care of
       b. Safety is your number one priority
          - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
       a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, 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
       c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Verify assigned/correct runway.
4. Ascertain wind direction with or without visible wind direction indicators.

5. Position the flight controls for the existing wind conditions.
6. Clear the area, taxi into takeoff position and align the airplane on the runway centerline utilizing maximum available takeoff area.
7. Apply brakes while setting aircraft power to achieve maximum performance.
8. Confirm takeoff power prior to brake release and verify proper engine and flight instrument indications prior to rotation
9. Rotate and lift off at the recommended airspeed and accelerate to the recommended obstacle clearance airspeed or V_X +10/-5 knots.
10. Establish a pitch attitude that will maintain the recommended obstacle clearance speed, or V_X +10/-5 knots, until the obstacle is cleared, or until the airplane is 50 feet above the surface.
11. After clearing the obstacle, establish the pitch attitude for V_Y, accelerate to V_Y, and maintain V_Y, +10/-5 knots, during the climb.
12. Configure the aircraft in accordance with aircraft manufacturer's guidance after a positive rate of climb has been verified.
13. Maintain V_Y +10/-5 knots to a safe maneuvering altitude
14. Maintain directional control and proper wind drift correction throughout takeoff and climb.
15. Comply with noise abatement procedures.

IV.F. Short-Field Approach and Landing

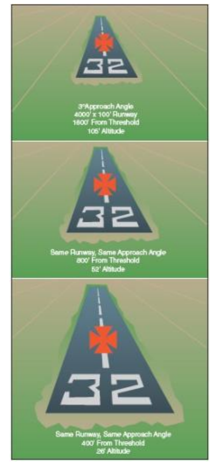
References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Stabilized Approach**
   A. A Stabilized Approach
      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.
         a. A stabilized approach is a safe approach
         b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
         c. Adjust Pitch for airspeed and Power for altitude to maintain speed and glidepath
            - Control is maintained this way because at the slow approach speeds we are flying on the backside of the power curve, or the region of reverse command
               a *If this is not the case for your aircraft, don't do this
   B. The Stabilized Short-Field Approach
      i. Generally, in the short-field approach, full flaps are used, the approach is started from at least 500' higher than the touchdown area, and a slower than normal approach speed is maintained
         a. Use the manufacturer's recommended speed – this speed is usually slower than a normal approach speed, allowing for a steeper descent rate
            - In the absence of the manufacturer's recommended speed, a speed of not more than 1.3 V_{SO} should be used. For example, if V_{SO} is 60 knots, the approach should be no faster than 78 knots.
               a In gusty air, no more than ½ the gust factor should be added
      ii. The slower airspeed and full flaps provide a steeper than normal descent rate allowing for obstacle clearance
         a. Set the approximate pitch and power in order to establish the aircraft in a descent at this speed – make adjustments as necessary in order to maintain the descent rate and the aim point
         b. A normal approach is approximately a 3-degree glidepath, while a short-field approach is closer to a 4-degree approach in order to clear the obstacle(s) on the approach end, and the slower airspeed helps the aircraft to stop in a shorter distance
      iii. Controlling Descent
         a. Adjust power and pitch as necessary to maintain a stabilized approach and glide slope
            - Region of Reverse Command
               a Below LD_{MAX}
               b Use pitch for airspeed and power for altitude
                  1. Pitching up decreases airspeed and vice versa
                  2. Increasing power decreases your rate of descent and vice versa
               c Trim the control forces to maintain airspeed
         b. A change in any of the variables requires a coordinated change in the other controllable variables
            - EX: Why do we never try to stretch the gliding distance with back pressure alone?
               a If the Pitch attitude is raised too high without increasing power this will cause the airplane to settle rapidly, short of the desired landing spot

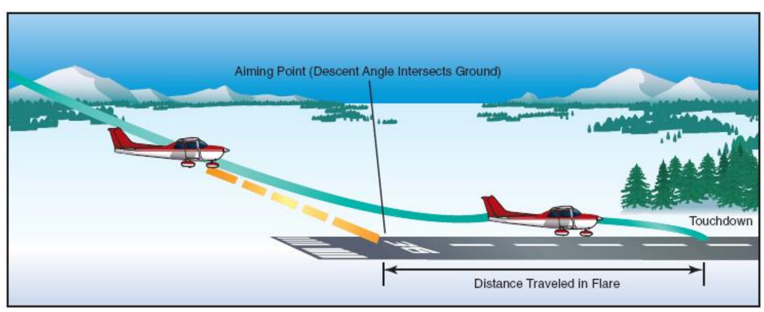
        1. The gliding distance is shortened if power is not increased simultaneously
- Proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
    a If the approach is too high, lower the nose and reduce power
    b If the approach is too low, add power and raise the nose
    c Stay on airspeed



iv. The Angle of Descent

a. Aiming Points
- The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
- Select a point in front of the point of intended touchdown
    a Normally this point is approximately 400 to 500’ in front of touchdown to allow for the airplane’s float. Because of the steeper glidepath and slower airspeed, this distance should be reduced
        1. The distance might be somewhere near 200-300’ prior to the touchdown point, but will vary based on the aircraft, configuration, weight, and wind conditions.
        2. This is equal to about 1 to 1½ stripes prior to your intended touchdown point
- Keep the aiming point steady on the wind screen
    a To a pilot moving straight ahead toward an object, the aiming point appears to be stationary, it does not move.
    b If the point begins to move up on the windscreen the airplane is getting too low
        1. Add power and raise the nose (maintain airspeed – the same airspeed with a higher power setting will result in a slower descent or climb)
    c If the point begins to move down on the windscreen the airplane is getting too high
        1. Reduce power and lower the nose (maintain airspeed – the same airspeed with a lower power setting will result in a steeper descent)
    d Small, active corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway
    e Airspeed remains constant throughout the approach

b. The Runway Image
- Too High
    a The runway will elongate and become narrower
        1. Overhead view of the runway



- Too Low
    a The runway will shorten and become wider
        1. Flat view of the runway
- On Descent Path
    a The runway will be between overhead and flat
    b The runway shape remains the same but grows in size as we approach

v. Objective of a Stabilized Approach

a. To select an appropriate touchdown point on the runway, and adjust the glidepath as necessary to roundout at or above the aiming point, providing distance for the flare to touchdown at the landing point

C. Energy Management
  i. A stabilized approach is based on well executed energy management
    a. As mentioned above, during the approach to final you are in the region of reverse command; power controls your rate of descent and pitch controls your airspeed
    b. A short-field approach is based on a 4-degree glidepath (this translates to 400’ per nautical mile). Therefore, you should be 400’ above the touchdown zone elevation one mile from touchdown, and 800’ two miles from touchdown
      - This should give you a general idea if you’re on or off glidepath during the approach (if you’re able to recognize your distance from the runway)
      - The ability to recognize a steeper, 4-degree approach path comes with practice and experience. If possible, find ground reference points at your home airport to monitor your descent.
    c. Once configured for the approach, set the approximate pitch attitude and power setting for approach speed
      - The more familiar you are with the approximate pitch and power settings, the easier it will be to manage your energy and maintain a stabilized approach
      - Once the approximate pitch and power setting is established, trim the control forces and crosscheck the airspeed, altitude, and glidepath
      - Make adjustments to establish yourself on a 4-degree glidepath while maintaining approach speed
        a Increase power to decrease your rate of descent. A coordinated increase in pitch will be required to maintain approach speed
          1. Increased power without a change in pitch will increase airspeed
        b Decrease power to increase your rate of descent. A coordinated decrease in pitch will be required to maintain approach speed
          1. Decreased power without a change in pitch will decrease airspeed
        c The key to stabilized, well managed, approaches is coordinated inputs between pitch and power in order to maintain a 4-degree glidepath to your aiming point at approach speed
    d. “Go ugly early”
      - Make corrections early. Don’t make a gradual correction to the glidepath or centerline of the runway, establishing yourself just prior to touchdown. This is unsafe.
        a You should be established on glidepath and course by 300’.
          1. This is a technique, but set a personal minimum where you will initiate a go around if you are not stabilized - on glidepath, airspeed, and runway course
      - If you realize you are off altitude or course, “go ugly early”
        a Make the necessary correction to reestablish yourself on glidepath and course as early as possible
        b The earlier you are stable, the safer the approach
          1. Of course, don’t be overly aggressive with the aircraft at slow airspeeds near the ground.
        c For example, if you roll out a quarter to a half mile off centerline don’t make a slow adjustment back to centerline, arriving just before touchdown. As soon as you see the mistake, make the required corrections to get established and stabilized early

            1. Yes, the approach will look "ugly early" (you may have to make a considerable correction back to centerline) but it is far safer to be established early than not be stabilized close to the ground

2. Effects of Atmospheric Conditions, Including Wind, on Approach and Landing Performance

- A. Density Altitude
  - i. Density altitude is pressure altitude adjusted for non-standard temperature
  - ii. Increased density altitude (lower pressure and/or higher temperature) increases the landing speed
    - a. The aircraft lands at the same indicated airspeed, but because of reduced density (which can be a result of a lower pressure and/or a higher temperature), the true airspeed is greater
      - The higher the altitude, the higher the true airspeed (it takes a greater speed to create the same amount of lift in the thinner air at high altitude than the thicker air near sea level)
- B. Wind
  - i. Approach
    - a. A headwind on approach decreases the aircraft's groundspeed. Because the aircraft is traveling at a slower speed, the rate of descent necessary to maintain a stable 4-degree path will need to be decreased as well
      - It will take longer to travel the same distance as if there was no wind, therefore the rate at which the aircraft descends needs to be reduced
    - b. A tailwind on the other hand increases the groundspeed and because the aircraft is traveling at a higher-than-normal speed, the rate of descent to maintain a 4-degree path will need to be increased
  - ii. Landing
    - a. A headwind during landing helps to reduce the landing ground roll while a tailwind increases the ground roll
      - In both cases the aircraft touches down with the same indicated airspeed, but with a headwind, the aircraft touches down at a lower ground speed and therefore can stop sooner than an aircraft with a tailwind (higher groundspeed on touchdown)

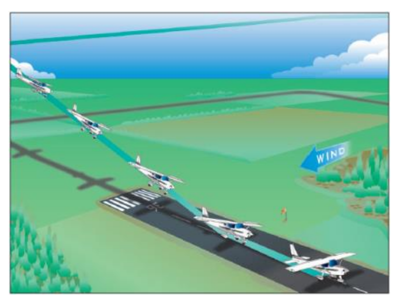
3. Wind Correction Techniques on Approach and Landing

- A. Crosswind Basics
  - i. Imagine a 20kt headwind, directly down the runway
    - a. On the downwind leg you're flying with a tailwind, and the groundspeed is 20 knots higher than true airspeed
      - The crosswind leg now has a significant crosswind and heading will have to be adjusted to maintain your track
      - On final, the aircraft will begin to slow as the crosswind turns into a headwind, slowing the aircraft 20 knots
        - a A strong headwind slows your groundspeed, therefore the stronger the headwind, the lower your rate of descent to reach the runway
          1. The opposite applies, if you had a strong tailwind, you would need to descend faster since you are traveling faster than if you had zero wind or a headwind
      - Headwind on Approach = Slower descent rate (since you're traveling slower)
  - ii. Crosswind Basics in the Pattern
    - a. Adjust each leg to maintain a rectangle track – turn the aircraft into the wind to maintain the traffic pattern
    - b. Crosswinds on the runway result in overshooting or undershooting winds in relation to your turn to final

- Imagine you are landing on runway 36 and have a wind from 060 degrees (a crosswind from the right on landing) this will result in an undershooting wind during the turn to final in left traffic and an overshooting wind in right traffic
  - a What this means is that using a normal amount of bank, as you make the turn to final the crosswind will either prevent you from reaching the runway centerline (undershooting) or push you past the runway centerline (overshooting)
  - b An undershooting wind will require less bank to align with the runway centerline and an overshooting wind will require more bank
    1. Always stay coordinated in your turns
- Basic Rule: On downwind, if the wind is blowing you away from the runway, you have an undershooting wind. If the wind is blowing you toward the runway, you have an overshooting wind. Adjust as necessary.

B. Approach and Landing
  i. The principal effect of wind on landing distance is to change the groundspeed at which the aircraft touches down
    a. A headwind decreases the groundspeed at which the aircraft touches down, thus decreasing the landing roll
    b. A tailwind increases the groundspeed at which the aircraft touches down, thus increasing the landing roll
  ii. Crosswind Corrections
    a. Landing which must be made while the wind is blowing across rather that parallel to the landing direction
    b. The same basic principles apply to a crosswind and normal approach and landing
    c. Two methods of accomplishing a crosswind approach and landing
      - Crab Method
        - a Easier but requires a high degree of judgment and timing in removing the crab right before touchdown
        - b Not recommended
      - Sideslip (wing-low) Method
        - a Recommended

    d. Final Approach
      - Sideslip (Wing-Low)
        - a Align the airplane's heading with the centerline of the runway, noting the rate and direction of drift
        - b Promptly apply drift correction
          1. Lower the upwind wing
             a. Amount of lowering depends on the drift
             b. When the wing is lowered, the airplane will turn in that direction, so simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane in aligned with the runway



          2. The airplane will be side-slipping into the wind just enough so that the flight path and ground track are aligned with the runway
          3. Changes in the crosswind are corrected for accordingly
        - c Strong Crosswind
          1. In the case that it is not possible to maintain the centerline, the wind is too strong to safely land on the particular runway

        a. In this case, there is insufficient rudder to maintain a heading with the required bank application
        b. The landing should be made on a more favorable runway
      d Maintain a stabilized approach
        1. Same as discussed above, except with the added side slip
        2. Because you are in a slip, drag is increased, more power will be necessary to maintain a given descent rate
  e. Roundout
    - Generally made like a normal landing approach, but the crosswind correction is continued as necessary to prevent drifting
      a Don't level the wings
        1. This will result in drifting, which results in side loading the gear
    - Gradually increase the deflection of the elevators and rudder to maintain drift correction as the airplane slows
      a The controls become less and less effective as airspeed is decreased
  f. Touchdown
    - The touchdown should be made on the upwind main wheel first
      a Maintaining crosswind correction to prevent drift
    - As the momentum decreases, the weight of the airplane will cause the downwind main wheel to gradually settle onto the runway, then the nosewheel
  g. After Landing Roll
    - Maintain directional control with rudders
      a With a greater profile behind the main wheels, the airplane will tend to weathervane into the wind
    - Maintain crosswind control with ailerons
      a Full aileron into the wind
        1. Keeps the upwind wing from rising
      b As the speed decreases, increasing aileron is going to be necessary

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

A. Pilot Capability
  i. Not only should a pilot have personal weather minimums, but also runway minimums
    a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
      - This is especially important in regards to a short-field landing
    b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
    c. These limitations may vary based on whether the runway is wet or dry or other factors
B. Aircraft Performance and Limitations and the Available Distance
  i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
    a. Do not attempt to takeoff or land from a runway that is not supported by the landing data

b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe approach and landing
  - Take into account the runway distance available as well as potential obstacles on the approach or in the case of a go around

ii. Do not exceed any flight limitations – follow the flight manual

iii. Calculate landing distance based on the current atmospheric conditions using the manufacturer's landing distance tables
  a. Using METAR and TAF information (depending on when you intend to land) obtain landing distance with the landing distance charts in the flight manual
  b. The landing distance should be compared to the runway available
  c. Landing Distance will vary based on factors such as weight, density altitude, runway surface and gradient, wind conditions, etc.

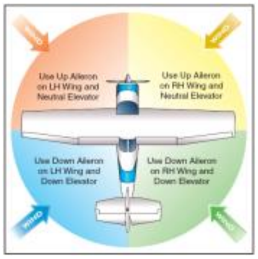
iv. Factors affecting Landing Distance
  a. Weight
    - Higher weights increase landing distance
  b. Wind
    - Increased Headwinds decrease landing distance
  c. Pressure/Density Altitude
    - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases landing distance
  d. Runway Slope and Condition
    - An inclined runway will decrease landing distance
    - Different types of runways can affect the landing distance
      a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual

C. The most favorable runway for landing meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
  i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
    a. This runway may be more favorable because it is aligned with your arrival direction, it may be a shorter taxi, it may be a longer runway, or it may provide a safer approach or climb out in the case of a go around
      - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

2. Crosswind

A. While usually preferable to land directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind
  i. See above for information on how to handle crosswinds safely
    a. The main idea is to use the ailerons to keep the aircraft centered on the runway and use the rudder to keep the longitudinal axis of the aircraft lined up with the centerline of the runway. This is to keep the aircraft on the runway and prevent damaging the gear

B. Crosswinds and Taxiing
  i. Taxiing with a tailwind
    a. Usually will require less engine power after the initial ground roll is begun
    b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally



- ii. Taxiing with a quartering headwind
  - a. Ailerons are turned into the headwind and the elevator is held neutral
  - b. 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
  - c. Also, the downwind aileron will be DOWN
    - A small amount of lift/drag is put on this wing keeping the upwind wing down

- iii. Taxiing with a Quartering Tailwind
  - a. Ailerons are turned with the wind and the elevator is DOWN
    - Dive with the Wind
    - This reduces the tendency of the wind to nose the plane over
    - The upwind aileron is DOWN in this case (opposite of a head wind)
- iv. These corrections minimize weathervaning and provide easier steering
- v. Always know the direction of the wind in relation to the airplane
  - a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Maximum Demonstrated Crosswind Component
- i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft
  - a. Prior to landing use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
    - If this exceeds the maximum demonstrated crosswind component, landing is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used
  - b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?
- i. Unexpected change in wind direction and/or wind speed
- ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?
- i. It is often associated with thunderstorms
  - a. Microbursts
    - These can be extremely dangerous
- ii. Inversion layer
  - a. Sometimes an inversion layer will result in a wind shift during descent

C. Dealing with it
- i. Avoid It!
  - a. DO NOT FLY if there is potential for wind shear
  - b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
  - c. LLWAS (Low Level Wind Shear Alerting System)
    - Most major airports have an LLWAS
    - If available, it can warn of impending wind shear
    - PIREPS can be very informational

            a Direct reports from other pilots who experienced the wind shear

   ii. Approach into Wind Shear
      a. If an option, divert to an airport with favorable weather conditions, otherwise,
         - Use more power
         - Maintain a Faster approach airspeed
            a Add ½ the gust factor to the approach speed
         - Stay as high as feasible until necessary to descend
         - Go Around at the first sign of a change in airspeed or unexpected pitch change
            a Important to get FULL power and get the aircraft into a max performance climb

4. Tailwind

A. A tailwind increases the runway required for landing
   i. Always verify the wind conditions and landing performance obtained are compatible with the runway of intended use

B. The flight manual will publish a maximum tailwind for landing, do not exceed this limit

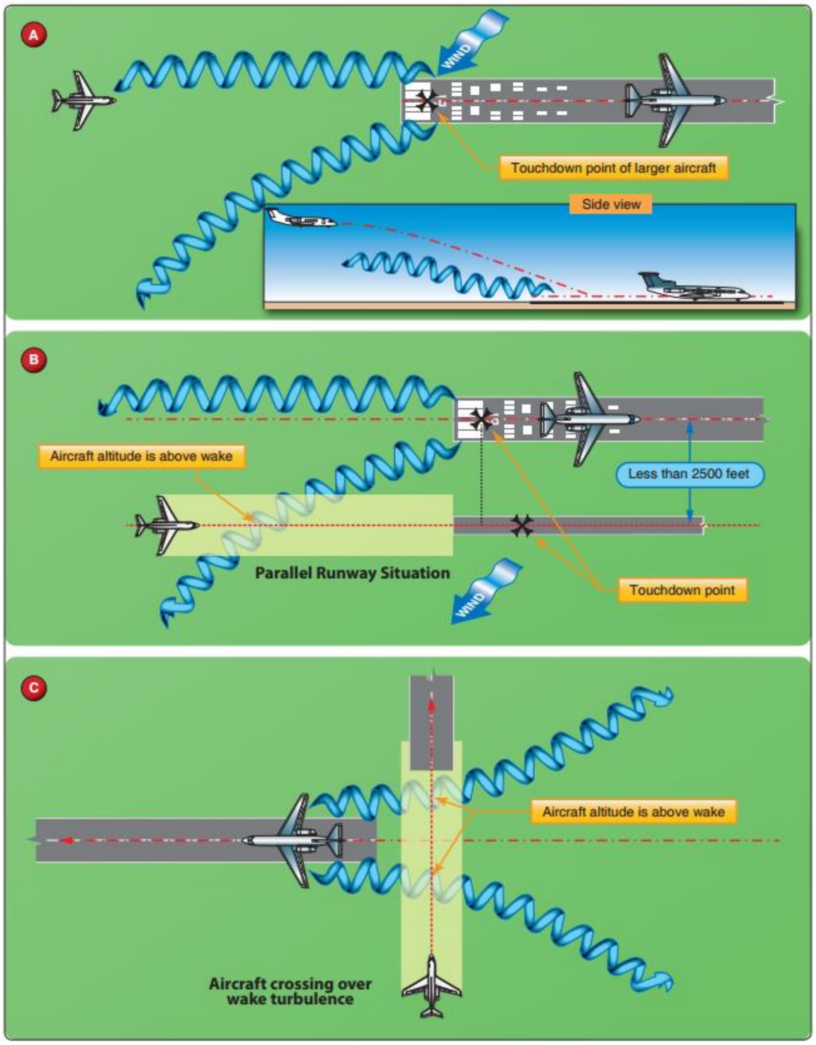
C. Use the performance charts to verify takeoff performance with the projected winds

5. Wake Turbulence

A. All aircraft generate wake turbulence during flight.
   i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
   ii. The vortices from larger aircraft pose problems to aircraft encountering them
      a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft

B. Wake Turbulence Recognition in the Terminal Area
   i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
   ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
      a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft

C. Wake Turbulence Resolution
   i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
      a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
      b. Crossing runways – cross above the larger jet's flight path
   ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. **Runway Surface/Condition**
   A. Runway conditions affect takeoff performance
      i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces
   B. Surface
      i. Runway surfaces vary widely. The runway surface may be concrete, asphalt, gravel, dirt, or grass
         a. The runway surface for a particular airport can be found in the Chart Supplement
         b. Any surface that is not hard (grass, dirt, etc.) decreases the ground roll during landing
            - Tires sink into soft runways and the tires do not roll smoothly over the surface
            - Be sure to incorporate soft-field procedures into the short-field landing if landing on a short dirt or grass strip
               a Balance the need for a firm touchdown with a safe soft field touchdown to avoid getting stuck or cartwheeling. Hold the nose off the runway as much as possible while balancing the need to stop quickly
               b This can be a difficult task, be very competent with the operations and ensure both you and the aircraft have the ability to accomplish the landing
      ii. Braking effectiveness is another consideration when dealing with different runway types

a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft

iii. The gradient of the runway can also have an effect on the landing ground roll
   a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3’ for every 100’ of runway length
   b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
   c. An upsloping runway assists deceleration and decreases the takeoff roll

C. Condition
   i. Braking effectiveness comes into play for different runway conditions
      a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to stop the aircraft
         - Water decreases the friction between the tires and the ground, reducing braking effectiveness
         - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway’s surface – braking and directional control are almost nil.
            a Grooved runways help to reduce hydroplaning
            b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
         - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
            a Use aerodynamic braking to its fullest advantage

D. Length
   i. Runway length obviously needs to accommodate the landing distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
   ii. Never attempt a landing on a runway that is not supported by the landing data
   iii. Ensure that runways are adequate in length for landing when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for:

A. Rejected Landing and Go-Around
   i. General
      a. Depending on the situation you may have to choose between a go around to handle an emergency airborne or continuing to land.
         - Go Around
            a There are situations that can be better handled airborne than on the ground
               1. If you get an emergency close to the ground (that doesn’t affect the aircraft’s ability to fly) and could create a hazard during landing, whether as a distraction or in relation to the safety of the aircraft it may be better to go around
               2. For example: landing gear problems. Go around and attempt to solve the problem airborne
         - Continue to Land
            a There are many situations that can be better handled by continuing the landing instead of going around to attempt to fix the problem
               1. If you experience an emergency that can affect the airplane’s ability to fly, it is likely best to continue to land the aircraft
               2. For example: if the engine starts running rough at 500’, do not attempt to go around as it may exacerbate the problem and quickly lead to an emergency landing

b. This is a very basic, surface level discussion as to whether go around or continue to land. These emergencies are aircraft and situation dependent, there may not necessarily be a correct procedure (go around or land), and depends on the pilot in commands discretion
c. Hindsight is always 20/20. Take time to review and learn from NTSB accident reports, and consider how you would handle different situations.

ii. Go Arounds Are Free
  a. If you're ever in doubt of the safety of the approach, go around and try it again
  b. Maintain a stabilized approach
    - Stable means on airspeed, glidepath, and runway centerline
      a Momentary deviations from speed, glidepath and centerline are acceptable
    - Set limits for airspeed/altitude requirements and an altitude at which if you are outside any of these limits you will go around – no questions asked
      a For example, ±5 knots and within 50' of altitude within a half mile of the runway (150' AGL)
        1. Assuming a 3-degree glidepath, you should be 300' AGL one mile out and 600' AGL 2 miles out, etc. Unless you have ground references at these points, recognizing this will come with experience
        2. If you are outside of these tolerances, the approach is unstable and it is time to go around

iii. Delaying the go-around often stems from two sources:
  a. Landing expectancy
    - The set anticipatory belief that conditions are not as threatening as they are and that the approach will surely end with a safe landing
  b. Pride
    - The mistaken belief that a go around is an admission of failure
  c. Understand these conditions and don't let them influence your decision to go around

B. Land and Hold Short Operations (LAHSO)

i. LAHSO operations may be in effect when simultaneous operations are being conducted on intersecting runways
  a. The idea is to allow simultaneous takeoffs and landings on intersecting runways
  b. ATC will clear an aircraft to land and hold short (stop before crossing the intersecting runway) to allow use of the intersecting runway
    - Runway holding position signs and markings are installed on runways prior to the intersection at which you need to hold short

ii. As Pilot in Command, you have the final authority to accept of decline any LAHSO clearance
  a. You are never required to accept the clearance, if you are uncomfortable simply reply "unable" to ATC
  b. If you accept a LAHSO clearance you must comply so that no portion of the aircraft extends beyond the hold markings

iii. The holding position sign has a white inscription with a black border around the numbers on a red background and is installed adjacent to the holding position markings

iv. 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. Know what signs and markings are at the LAHSO point
  e. LAHSO are not authorized for student pilots who are performing a solo flight
  f. At many airports, air carriers are not authorized LAHSO if the other aircraft is general aviation

g. Generally, LAHSO are not authorized at night
h. LAHSO are not authorized on wet runways

8. Collision Hazards

A. Aircraft

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept
b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other’s right has the right-of-way.
    - If they are different categories:
        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
c. Approaching Head-on
    - Each pilot shall alter course to the right
d. Overtaking
    - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
e. Landing
    - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
    - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        a Don’t take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
    - 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
    - Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Clearing Procedures
    a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
    b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
        - This is also more applicable to cruise, but can be used while the pattern, if necessary
    c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
    a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
        - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing especially on a short field runway in which an obstacle is likely at the approach end
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
        - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires
    a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
    b. These wires and lines may or may not be lighted
    c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft

a. Ensure proper clearance between the aircraft and obstacle
- If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.

i. Be alert for anyone/anything that may cause a hazard

a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
- Be cautious
- Initiate a go-around, if required

b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
- It may be necessary to go-around in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering

A. Low Altitude Maneuvering

i. A small problem at high altitude can quickly become a big problem at a low altitude

a. There is considerably less time to handle any issues at a low altitude

b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
- Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
- The aircraft is slower than normal during a short-field approach and therefore closer to the stall speed. Precise control is integral to a safe and stable approach

ii. Be aware of, and avoid obstructions on and around the airfield

a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground

b. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin

i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.

a. Airspeed
- Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach.
  - a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
- If you get any indication of a stall at low level, recover from the stall and go around
  - a Max, Relax, Roll is a common memory aid for stall recovery
    1. Apply max power
    2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
    3. And roll wings level

b. Cross Controlled Stall
- Here's a situation that will lead to a cross-controlled condition in the pattern:
  - a In a descent, the pilot starts the left turn from base to final late, additionally there's an overshooting wind pushing the aircraft past the runway centerline and potentially into the final approach of a parallel runway

b. In order to attempt to fix the problem, the pilot rolls to 30° of bank, knowing that is the limit for safe bank in the pattern, but 30° of bank is not enough to line aircraft up with the centerline, an overshoot is inevitable
    1. In order to correct, and avoid the parallel runway's final approach area, the pilot adds left rudder (trying to force the airplane around the corner and avoid the overshoot), while maintaining 30° of bank
        a. The left rudder pushes the nose around, and also increases lift on the right wing (the yaw swings the right wing around, moving it faster than the left, increasing lift)
        b. As lift increases on the right wing, the aircraft rolls left, the pilot applies right aileron to maintain 30° of bank
            i. The aircraft is now in an uncoordinated cross-controlled situation - Left rudder and right aileron

c. This can quickly lead to a very dangerous cross-controlled stall. One in which the aircraft may roll over (almost, if not fully inverted). The natural reaction of rolling in the opposite direction only intensifies the stall. This is likely unrecoverable at low altitudes. Maintain coordination!

ii. Spin
    a. A spin is a result of a stall + yaw
        - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
    b. Prevention
        - Maintain coordination
        - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
        - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
    d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. The majority of CFIT incidents occur during final approach and landing
        b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
        c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    iii. Recommendations:
        a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
        b. Know and fly above minimum published safe altitudes.
            - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
 i. In the descent, approach, traffic pattern, and landing, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.
 ii. At a controlled field, listen to ATC's instructions
  a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
 iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
 iv. Fly first!
  a. Aviate, Navigate, Communicate
 v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
 vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
  a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air
 i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
 ii. There is no place for distractions in the traffic pattern and in the runway environment
 iii. Maintain situational awareness
  a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
 i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
  a. No one responsibility should take your full attention full more than a short period
   - Continually move between tasks to ensure everything is being taken care of
  b. Safety is your number one priority
   - Aviate, Navigate, Communicate
 ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.

    a. Checklists are extremely helpful in properly managing tasks

iii. Recognize when you are getting behind the aircraft, and find a way to catch up

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Ensure the aircraft is aligned with the correct/assigned runway.
4. Scan the landing runway and adjoining area for traffic and obstructions.
5. Consider the wind conditions, landing surface, obstructions, and select a suitable touchdown point.
6. Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
7. Maintain manufacturer's published airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots, with wind gust factor applied
8. Maintain crosswind correction and directional control throughout the approach and landing sequence.
9. Make smooth, timely, and correct control inputs during round out and touchdown.
10. Touch down at a proper pitch attitude, within 200 feet beyond the specified point, threshold markings or runway numbers, with no side drift, minimum float, and with the airplane's longitudinal axis aligned with and over runway centerline
11. Use manufacturer's recommended procedures for aircraft configuration and braking.
12. Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
13. Utilize runway incursion avoidance procedures.

IV.M. Forward Slip to a Landing

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Concepts of Energy Management During a Forward Slip Approach**
    A. Forward Slip
        i. What is a Forward Slip?
            a. A forward slip is a slip in which the aircraft's direction of motion continues the same as before the slip was begun
            b. Assuming the aircraft is in straight flight, the wing on the side toward which the slip is to be made should be lowered by use of the ailerons. Simultaneously, the aircraft's nose must be yawed in the opposite direction by applying opposite rudder so that the aircraft's longitudinal axis is at an angle to the original flight path
                - The degree to which the nose is yawed in the opposite direction from the bank should be such that the original ground track is maintained.
                - The amount of slip, and therefore the sink rate, is determined by the bank angle
                    a The steeper the bank, the steeper the descent
    B. Energy Management
        i. Adjust bank angle and corresponding rudder input in order to increase or decrease your rate of descent (power should be at idle)
            a. More aileron/bank = a greater descent rate
        ii. Be careful, as large aileron and rudder inputs can result in high rates of descent and can be hazardous near the ground
    C. Practical Slip Limit
        i. The point may be reached where full rudder is required to maintain heading even though the ailerons are capable of steeper the bank
            a. This is the Practical Slip Limit: Any additional bank will cause the airplane to turn even though full opposite rudder is being applied
        ii. If there is a need to descend faster even though the Practical Slip Limit has been reached, lowering the nose will increase the sink rate but will also increase airspeed
            a. The increase in airspeed increases rudder effectiveness permitting a steeper slip
            b. Conversely, when the nose is raised, rudder effectiveness decreases and the bank angle must be reduced
    D. Remember, a stabilized slip is a safe slip; an un-stabilized slip increases the potential for a cross controlled stall
2. **Effects of Atmospheric Conditions, Including Wind, on Approach and Landing Performance**
    A. Density Altitude
        i. Density altitude is pressure altitude adjusted for non-standard temperature
        ii. Increased density altitude (lower pressure and/or higher temperature) increases the landing speed
            a. The aircraft lands at the same indicated airspeed, but because of reduced density (which can be a result of a lower pressure and/or a higher temperature), the true airspeed is greater
                - The higher the altitude, the higher the true airspeed (it takes a greater speed to create the same amount of lift in the thinner air at high altitude than the thicker air near sea level)
    B. Wind

i. Approach
    a. A headwind on approach decreases the aircraft's groundspeed. Because the aircraft is traveling at a slower speed, the rate of descent necessary to maintain a stable 3-degree path will need to be decreased as well
        - It will take longer to travel the same distance as if there was no wind, therefore the rate at which the aircraft descends needs to be reduced
    b. A tailwind on the other hand increases the groundspeed and because the aircraft is traveling at a higher-than-normal speed, the rate of descent to maintain a 3-degree path will need to be increased

ii. Landing
    a. A headwind during landing helps to reduce the landing ground roll while a tailwind increases the ground roll
        - In both cases the aircraft touches down with the same indicated airspeed, but with a headwind, the aircraft touches down at a lower ground speed and therefore can stop sooner than an aircraft with a tailwind (higher groundspeed on touchdown)

3. Wind Correction Techniques During Forward Slip Procedures

A. Main Point:
  i. Always slip into the wind, this makes directional control and ground track considerably easier to maintain
    a. If you bank with the wind, the aircraft will have a tendency to drift off course

B. Entering the Forward Slip
  i. Checklists should be used as normal
  ii. Configuration
    a. The airplane will have to be established higher on final
        - This is because the slip will result in a steeper than normal descent
    b. Reduce power to idle
        - There is no logic in slipping to lose altitude with power in
        - Keep hand on throttle even though it is at idle, it may be necessary to immediately go around
  iii. Configure the aircraft as normal
    a. Slipping is not the first option when necessary to lose altitude, reduce power, lower the flaps, use spoiler (if available), and if still necessary to increase the rate of descent, then slip
    b. Slips are normally done with power at idle and flaps fully extended
  iv. Establish the Slip
    a. The wing on the side toward which the slip is to be made should be lowered by use of the ailerons
        - Slip into the wind, if a crosswind exists. This allows the pilot to increase or decrease bank as necessary to maintain the desired ground track
            a Wing down into the wind
            b Lowering the opposite wing would result in shallowed angles of bank in order to prevent the aircraft from drifting off course in the direction of the bank and the crosswind – the rudder can only do so much to maintain course
            c Banking into the wind allows the pilot to use more bank, establishing a greater descent rate while maintaining the course
    b. 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
        - The degree to which the nose is yawed should be such that the ground track is maintained

        a. If rudder application is delayed, the airplane will turn in the direction of the lowered wing
    c. The nose of the airplane should be raised to prevent the airspeed from increasing
        - Maintain airspeed, but be very cautious not to stall the aircraft

4. When and Why a Forward Slip Approach is Used

A. What is a Slip?
- i. A slip is a combination of forward movement and sideward movement
    - a. The airplane is in fact flying sideways resulting in a change in the direction the relative wind strikes the plane
- ii. Slips are characterized by
    - a. An increase in drag which allows for the airplane to descend rapidly without an increase in airspeed
    - b. And a corresponding decrease in airplane climb, cruise, and glide performance
- iii. Positive Static Stability
    - a. Most airplanes exhibit the characteristic of positive static directional stability and, therefore, have a natural tendency to compensate for slipping
        - An intentional slip, therefore, requires deliberate cross-controlling ailerons and rudder throughout the maneuver to maintain the side slip

B. The Forward Slip
- i. Overview
    - a. A forward slip is used to steepen the descent angle without excessively increasing the airspeed
        - A forward slip is useful in forced landings, in situations where obstacles must be cleared during approach to confined areas, or to increase the rate of descent when well above the desired glidepath (this can be particularly useful in both normal (power on) situations and emergency (no power) situations)
    - b. In a forward slip the aircraft descends with one wing lowered and the airplane's longitudinal axis at an angle to the flight path
        - The flight path remains the same as before the slip was begun, although the aircraft is at an angle to the intended track

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Selection of Runway based on Pilot Capability, Aircraft Performance and Limitations, Available Distance, and Wind

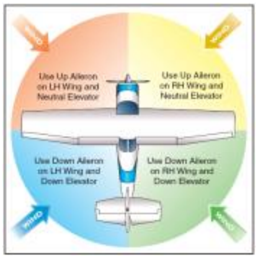
A. Pilot Capability
- i. Not only should a pilot have personal weather minimums, but also runway minimums
    - a. Set a minimum runway length and width that you are comfortable with based on the aircraft's limitations and abilities and your comfort/safety level
    - b. Set a maximum crosswind limitation based on your abilities and comfort/safety level
    - c. These limitations may vary based on whether the runway is wet or dry or other factors

B. Aircraft Performance and Limitations and the Available Distance
- i. Prior to every flight the FARs (91.103) require that the pilot become familiar with all available information concerning the flight. This must include runway lengths and takeoff and landing distance data from the flight manual
    - a. Do not attempt to takeoff or land from a runway that is not supported by the landing data

        b. Aircraft performance will vary based on the atmospheric conditions and aircraft configuration (passengers, fuel load, cargo, etc.). Always ensure the performance capabilities of the aircraft allow for a safe approach and landing
            - Take into account the runway distance available as well as potential obstacles on the approach or in the case of a go around
    ii. Do not exceed any flight limitations – follow the flight manual
    iii. Calculate landing distance based on the current atmospheric conditions using the manufacturer's landing distance tables
        a. Using METAR and TAF information (depending on when you intend to land) obtain landing distance with the landing distance charts in the flight manual
        b. The landing distance should be compared to the runway available
        c. Landing Distance will vary based on factors such as weight, density altitude, runway surface and gradient, wind conditions, etc.
    iv. Factors affecting Landing Distance
        a. Weight
            - Higher weights increase landing distance
        b. Wind
            - Increased Headwinds decrease landing distance
        c. Pressure/Density Altitude
            - A lower pressure/density altitude (more pressure) creates more engine power and therefore decreases landing distance
        d. Runway Slope and Condition
            - An inclined runway will decrease landing distance
            - Different types of runways can affect the landing distance
                a For example, paved vs unprepared (grass, or dirt strips). There is much more ground friction on grass or dirt strips as compared to a paved strip. Adjust as necessary in the flight manual
C. The most favorable runway for landing meets the performance requirements (runway length, climb requirements, etc.) and is most closely aligned with the wind (headwind, not tailwind)
    i. Occasionally, you may prefer a runway that is not most closely aligned with the wind
        a. This runway may be more favorable because it is aligned with your arrival direction, it may be a shorter taxi, it may be a longer runway, or it may provide a safer approach or climb out in the case of a go around
            - Other runways can be used if performance and limitations, support them, the pilot is comfortable with the new runway, and ATC will allow it.

2. Crosswind

A. While usually preferable to land directly into the wind, there are many instances when circumstances or judgement dictate otherwise resulting in a crosswind
    i. See above for information on how to handle crosswinds safely
        a. The main idea is to use the ailerons to keep the aircraft centered on the runway and use the rudder to keep the longitudinal axis of the aircraft lined up with the centerline of the runway. This is to keep the aircraft on the runway and prevent damaging the gear
B. Crosswinds and Taxiing
    i. Taxiing with a tailwind
        a. Usually will require less engine power after the initial ground roll is begun
        b. To avoid overheating the brakes, keep engine power at a minimum and only apply them occasionally



ii. Taxiing with a quartering headwind
   a. Ailerons are turned into the headwind and the elevator is held neutral
   b. 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
   c. Also, the downwind aileron will be DOWN
      - A small amount of lift/drag is put on this wing keeping the upwind wing down

iii. Taxiing with a Quartering Tailwind
   a. Ailerons are turned with the wind and the elevator is DOWN
      - Dive with the Wind
      - This reduces the tendency of the wind to nose the plane over
      - The upwind aileron is DOWN in this case (opposite of a head wind)

iv. These corrections minimize weathervaning and provide easier steering
v. Always know the direction of the wind in relation to the airplane
   a. Use the heading indicator/heading bug (if available) to visualize the wind in relation to the airplane and position the controls accordingly

C. Maximum Demonstrated Crosswind Component
   i. The manufacturer's flight manual will specify the maximum demonstrated crosswind component for the aircraft
      a. Prior to landing use a calculator to figure out the crosswind component based on the current winds and the intended runway of use
         - If this exceeds the maximum demonstrated crosswind component, landing is not allowed and will have to be delayed until conditions improve or a different runway within limits can be used
      b. The aircraft may not be able to remain within the runway confines during approach and landing at crosswinds greater than the maximum demonstrated crosswind component

3. Wind Shear

A. What is it?
   i. Unexpected change in wind direction and/or wind speed
   ii. Can be extremely dangerous and result in excessive changes in lift and airspeed, especially for a small aircraft

B. Where is it?
   i. It is often associated with thunderstorms
      a. Microbursts
         - These can be extremely dangerous
   ii. Inversion layer
      a. Sometimes an inversion layer will result in a wind shift during descent

C. Dealing with it
   i. Avoid It!
      a. DO NOT FLY if there is potential for wind shear
      b. Never conduct traffic pattern operations (or any operations) in close proximity to an active thunderstorm
      c. LLWAS (Low Level Wind Shear Alerting System)
         - Most major airports have an LLWAS
         - If available, it can warn of impending wind shear
         - PIREPS can be very informational

- a Direct reports from other pilots who experienced the wind shear

ii. Approach into Wind Shear
   a. If an option, divert to an airport with favorable weather conditions, otherwise,
      - Use more power
      - Maintain a Faster approach airspeed
         - a Add ½ the gust factor to the approach speed
      - Stay as high as feasible until necessary to descend
      - Go Around at the first sign of a change in airspeed or unexpected pitch change
         - a Important to get FULL power and get the aircraft into a max performance climb

4. Tailwind

A. A tailwind during the descent increases the required rate of descent to reach the runway
   i. A higher groundspeed means the aircraft will travel the distance to the runway in a shorter time and therefore the rate of descent needs to be increased in order to compensate

B. A tailwind increases the runway required for landing
   i. Always verify the wind conditions and landing performance obtained are compatible with the runway of intended use

C. The flight manual will publish a maximum tailwind for landing, do not exceed this limit

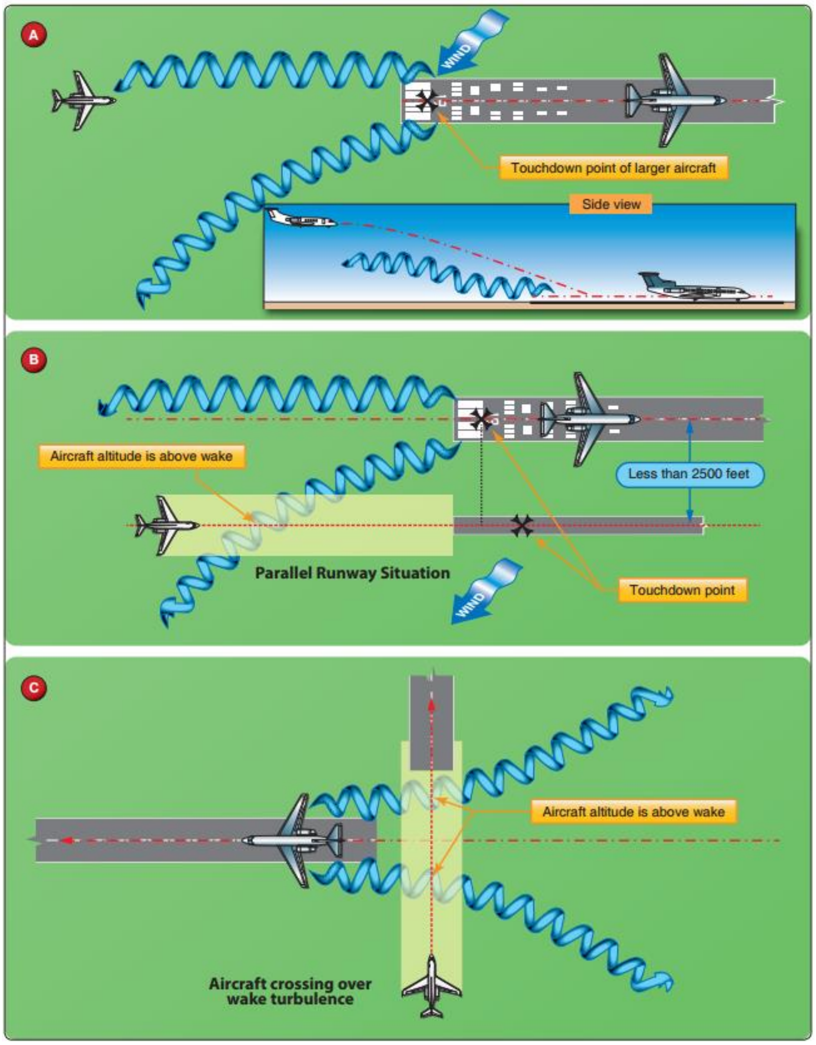
D. Use the performance charts to verify takeoff performance with the projected winds

5. Wake Turbulence

A. All aircraft generate wake turbulence during flight.
   i. This disturbance is caused by a pair of counter-rotating vortices trailing from the wingtips
   ii. The vortices from larger aircraft pose problems to aircraft encountering them
      a. The wake of these aircraft can impose rolling moments exceeding the roll authority of the encountering aircraft

B. Wake Turbulence Recognition in the Terminal Area
   i. Wake turbulence is affected by many factors (weight, speed, flaps, etc.)
   ii. The vortex strength increases proportionately with an increase in operating weight and decrease in speed
      a. The worst-case scenario is a HEAVY, SLOW, and CLEAN aircraft

C. Wake Turbulence Resolution
   i. Landing – Stay above and land beyond a landing jet's touchdown point; land prior to a departing jet's takeoff point
      a. Parallel runways – stay at and above the other jet's flight path for the possibility of drift
      b. Crossing runways – cross above the larger jet's flight path
   ii. Takeoff – Takeoff after a landing jet's touchdown point, and takeoff before and stay above another departing jet's path



6. Runway Surface/Condition

A. Runway conditions affect takeoff performance
   i. Typically, performance charts assume paved, level, smooth, and dry runway surfaces

B. Surface
   i. Runway surfaces vary widely. The runway surface may be concrete, asphalt, gravel, dirt, or grass
      a. The runway surface for a particular airport can be found in the Chart Supplement
      b. Any surface that is not hard (grass, dirt, etc.) decreases the ground roll during landing
         - Tires sink into soft runways and the tires do not roll smoothly over the surface
   ii. Braking effectiveness is another consideration when dealing with different runway types
      a. Although it is more difficult to accelerate on soft surfaces, it is often easier to stop the aircraft
   iii. The gradient of the runway can also have an effect on the landing ground roll
      a. Gradients are expressed as a percentage – a 3% gradient means that the runways height changes by 3’ for every 100’ of runway length
      b. A positive gradient indicates the runway height increases, and a negative gradient indicates the runway decreases in height
      c. An upsloping runway assists deceleration and decreases the takeoff roll

C. Condition

i. Braking effectiveness comes into play for different runway conditions
   a. Water or ice, for example, may make stopping more difficult and could significantly extend the distance required to stop the aircraft
      - Water decreases the friction between the tires and the ground, reducing braking effectiveness
      - Hydroplaning also is an issue. Dynamic hydroplaning is a condition in which the tires ride on a thin sheet of water rather than on the runway's surface – braking and directional control are almost nil.
         a Grooved runways help to reduce hydroplaning
         b The minimum speed for dynamic hydroplaning can be determined by multiplying the square root of the tire pressure by 9. Although, once started, hydroplaning can continue below this speed
      - On wet runways, land into the wind, do not use abrupt control inputs and anticipate reduced braking
         a Use aerodynamic braking to its fullest advantage

D. Length
   i. Runway length obviously needs to accommodate the landing distance required for the aircraft based on the atmospheric conditions and configuration of the aircraft
   ii. Never attempt a landing on a runway that is not supported by the landing data
   iii. Ensure that runways are adequate in length for landing when less than ideal runway surfaces and/or runway conditions are being reported

7. Abnormal Operations, to Include Planning for:

Note: The ACS mentions rejected takeoff and engine failure in the takeoff/climb phase. This does not appear to apply to a forward slip and therefore go-arounds and LAHSO operations are discussed instead)

A. Rejected Landing and Go-Around
   i. General
      a. When initiating a go-around during a forward slip, remove the slip and establish the proper climb attitude and configuration for the procedure
         - The slip is designed to increase drag and therefore would reduce the aircraft's performance during a go-around
      b. Depending on the situation you may have to choose between a go around to handle an emergency airborne or continuing to land.
         - Go Around
            a There are situations that can be better handled airborne than on the ground
               1. If you get an emergency close to the ground (that doesn't affect the aircraft's ability to fly) and could create a hazard during landing, whether as a distraction or in relation to the safety of the aircraft it may be better to go around
               2. For example: landing gear problems. Go around and attempt to solve the problem airborne
         - Continue to Land
            a There are many situations that can be better handled by continuing the landing instead of going around to attempt to fix the problem
               1. If you experience an emergency that can affect the airplane's ability to fly, it is likely best to continue to land the aircraft
               2. For example: if the engine starts running rough at 500', do not attempt to go around as it may exacerbate the problem and quickly lead to an emergency landing

c. This is a very basic, surface level discussion as to whether go around or continue to land. These emergencies are aircraft and situation dependent, there may not necessarily be a correct procedure (go around or land), and depends on the pilot in commands discretion
d. Hindsight is always 20/20. Take time to review and learn from NTSB accident reports, and consider how you would handle different situations.

ii. Go Arounds Are Free
   a. If you're ever in doubt of the safety of the approach, go around
   b. Maintain a stabilized approach
      - Stable means on airspeed, glidepath, and runway centerline
         a *Momentary* deviations from speed, glidepath and centerline are acceptable
      - Set limits for airspeed/altitude requirements and an altitude at which if you are outside any of these limits you will go around – no questions asked
         a For example, ±5 knots and within 50' of altitude within a half mile of the runway (150' AGL)
            1. Assuming a 3-degree glidepath, you should be 300' AGL one mile out and 600' AGL 2 miles out, etc. Unless you have ground references at these points, recognizing this will come with experience
            2. If you are outside of these tolerances, the approach is unstable and it is time to go around

iii. Delaying the go-around often stems from two sources:
   a. Landing expectancy
      - The set anticipatory belief that conditions are not as threatening as they are and that the approach will surely end with a safe landing
   b. Pride
      - The mistaken belief that a go around is an admission of failure
   c. Understand these conditions and don't let them influence your decision to go around

B. Land and Hold Short Operations (LAHSO)

i. LAHSO operations may be in effect when simultaneous operations are being conducted on intersecting runways
   a. The idea is to allow simultaneous takeoffs and landings on intersecting runways
   b. ATC will clear an aircraft to land and hold short (stop before crossing the intersecting runway) to allow use of the intersecting runway
      - Runway holding position signs and markings are installed on runways prior to the intersection at which you need to hold short

ii. As Pilot in Command, you have the final authority to accept of decline any LAHSO clearance
   a. You are never required to accept the clearance, if you are uncomfortable simply reply "unable" to ATC
   b. If you accept a LAHSO clearance you must comply so that no portion of the aircraft extends beyond the hold markings

iii. The holding position sign has a white inscription with a black border around the numbers on a red background and is installed adjacent to the holding position markings

iv. In the case a forward slip is required (i.e., high approach angle requiring a forward slip to reach the runway), consider declining the LAHSO clearance or initiating a go-around and setting up a more stable approach

v. 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. Know what signs and markings are at the LAHSO point
e. LAHSO are not authorized for student pilots who are performing a solo flight
f. At many airports, air carriers are not authorized LAHSO if the other aircraft is general aviation
g. Generally, LAHSO are not authorized at night
h. LAHSO are not authorized on wet runways

8. Collision Hazards to Include Aircraft, Terrain, Obstacles and Wires

A. Aircraft

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept
b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
   - If they are different categories:
     a A balloon has the right of way over any other category
     b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
     c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
     d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
c. Approaching Head-on
   - Each pilot shall alter course to the right
d. Overtaking
   - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
e. Landing
   - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
     a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
     a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
   - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons

    - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

  iv. Clearing Procedures
    a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
    b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary
    c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

  v. Scanning
    a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
  i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  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
      - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
  i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages
  ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
      - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
  iii. Overhead Wires
    a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
    b. These wires and lines may or may not be lighted

c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft

a. Ensure proper clearance between the aircraft and obstacle

- If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.

i. Be alert for anyone/anything that may cause a hazard

a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment

- Be cautious
- Initiate a go-around, if required

b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment

- It may be necessary to go-around in the case wildlife is on or approaching the runway. Err on the side of caution

9. Low Altitude Maneuvering

A. Low Altitude Maneuvering

i. A small problem at high altitude can quickly become a big problem at a low altitude

a. There is considerably less time to handle any issues at a low altitude

b. Therefore, avoid distractions, maintain situational awareness, and fly precisely

- Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)

ii. Be aware of, and avoid obstructions on and around the airfield

a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground

b. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin

i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.

a. Airspeed

- Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach.
  - a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
- If you get any indication of a stall at low level, recover from the stall and go around
  - a Max, Relax, Roll is a common memory aid for stall recovery
    1. Apply max power
    2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
    3. And roll wings level

b. Cross Controlled Stall

- Here's a situation that will lead to a cross-controlled condition in the pattern:
  - a In a descent, the pilot starts the left turn from base to final late, additionally there's an overshooting wind pushing the aircraft past the runway centerline and potentially into the final approach of a parallel runway

b. In order to attempt to fix the problem, the pilot rolls to 30° of bank, knowing that is the limit for safe bank in the pattern, but 30° of bank is not enough to line aircraft up with the centerline, an overshoot is inevitable
    1. In order to correct, and avoid the parallel runway's final approach area, the pilot adds left rudder (trying to force the airplane around the corner and avoid the overshoot), while maintaining 30° of bank
        a. The left rudder pushes the nose around, and also increases lift on the right wing (the yaw swings the right wing around, moving it faster than the left, increasing lift)
        b. As lift increases on the right wing, the aircraft rolls left, the pilot applies right aileron to maintain 30° of bank
            i. The aircraft is now in an uncoordinated cross-controlled situation - Left rudder and right aileron

c. This can quickly lead to a very dangerous cross-controlled stall. One in which the aircraft may roll over (almost, if not fully inverted). The natural reaction of rolling in the opposite direction only intensifies the stall. This is likely unrecoverable at low altitudes. Maintain coordination!

ii. Spin
    a. A spin is a result of a stall + yaw
        - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
    b. Prevention
        - Maintain coordination
        - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
        - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
    d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. The majority of CFIT incidents occur during final approach and landing
        b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
        c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    iii. Recommendations:
        a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
        b. Know and fly above minimum published safe altitudes.
            - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
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 outside the United States or 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.

10. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
  i. In the descent, approach, traffic pattern, and landing, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.
  ii. At a controlled field, listen to ATC's instructions
    a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be
  iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)
  iv. Fly first!
    a. Aviate, Navigate, Communicate
  v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
  vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air
  i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
  ii. There is no place for distractions in the traffic pattern and in the runway environment
  iii. Maintain situational awareness
    a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management
  i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.

        a. Checklists are extremely helpful in properly managing tasks
    iii. Recognize when you are getting behind the aircraft, and find a way to catch up
        a. If more time is needed, go around, find somewhere to hold/circle, or slow down
        b. Ask for assistance, if possible
        c. Don't give up or overstress yourself. Take it one step at a time.

11. Forward Slip Operations, Including Fuel Flowage, Tail Stalls with Flaps, and Lack of Airspeed Control

A. Fuel Flowage
    i. As long as the airplane is 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. But, if aileron and rudder are not coordinated (as in a forward slip) forces acting on the airplane may pull fuel away from the fuel lines. This can cause fuel starvation and engine stoppage.
        a. Obviously, the risk is greatest when fuel levels are low
    iii. Be cautious and remove the slip at any indication of engine coughing or roughness

B. Tail Stalls with Flaps
    i. It is not recommended to slip some aircraft with flaps extended, this is because it can result in a tail stall
        a. The conditions and reasons may vary between aircraft, but in general, having the flaps extended blanks out the relative wind over the horizontal stabilizer due to the alignment of the two in a slip and can result in a tail stall
    ii. Follow the manufacturer's recommendations, and remove the slip at any indication of stall

C. Lack of Airspeed Control
    i. Indicated vs True Airspeed and Slips
        a. Because of the location of the pitot tube and static vents, airspeed indicators in some airplanes may have considerable indicated airspeed errors when the airplane is in a slip
            - The pilot must be aware of this possibility and recognize a properly performed slip by
                a The attitude of the airplane
                b The sounds of the airflow
                c The feel of the flight controls
        b. Use any information provided in the POH as to the amount of error

D. Go Around
    i. Remember, unless absolutely necessary to slip to the landing, you can always simply execute a go around and start the approach again from an altitude that does not require a slip.
        a. There's no need to create an unnecessarily unsafe situation

12. Surface Contact with the Airplane's Longitudinal Axis Misaligned

A. It is extremely important the aircraft's longitudinal axis is parallel to the direction the aircraft is traveling along the runway (aligned with the centerline) when landing. Failure to accomplish this can impose severe side loads on the landing gear and could lead to damage or gear collapse
    i. To avoid these side stresses, do not allow the aircraft to touchdown while in a forward slip
    ii. The forward slip should be entirely removed, and a side-slip used if necessary to correct for any crosswind

13. Unstable Approach

A. A stable approach is one in which the pilot establishes and maintains a constant angle glidepath towards a predetermined point on the landing runway.
    i. A stabilized approach is a safe approach
    ii. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground and can lead to hazardous situations

B. Excessive rates of descent are an example of an unstable approach. Rather than forward slipping, it may be safer (depending on the situation) to simply go-around and establish a stable approach to landing

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Plan and follow a flightpath to the selected landing area considering altitude, wind, terrain, and obstructions.
4. Select the most suitable touchdown point based on wind, landing surface, obstructions, and aircraft limitations.
5. Position airplane on downwind leg, parallel to landing runway
6. Configure the airplane correctly.
7. As necessary, correlate crosswind with direction of forward slip and transition to side slip before landing.
8. 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.
9. Maintain a ground track aligned with the runway center/landing path.

IV.N. Go-Around/Rejected Landing

References: Airplane Flying Handbook (FAA-H-8083-3), POH/AFM

KNOWLEDGE

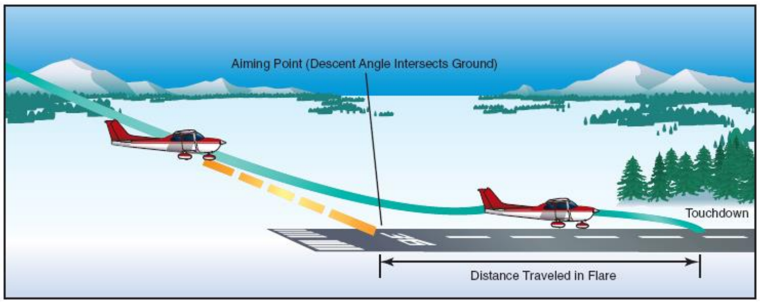
The applicant demonstrates understanding of:

1. **A Stabilized Approach to Include Energy Management Concepts**
    A. A Stabilized Approach
        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.
            a. A stabilized approach is a safe approach
            b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
            c. Adjust Pitch for airspeed and Power for altitude to maintain speed and glidepath
        ii. Controlling Descent
            a. Adjust power and pitch as necessary to maintain a stabilized approach and glide slope
                - Region of Reverse Command
                    a Below LD_{MAX}
                    b Use pitch for airspeed and power for altitude
                        1. Pitching up decreases airspeed and vice versa
                        2. Increasing power decreases your rate of descent and vice versa
                    c Trim the control forces to maintain airspeed
            b. A change in any of the variables requires a coordinated change in the other controllable variables
                - EX: Why do we never try to stretch the gliding distance with back pressure alone?
                    a If the Pitch attitude is raised too high without increasing power this will cause the airplane to settle rapidly, short of the desired landing spot
                        1. The gliding distance is shortened if power is not increased simultaneously
                - Proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
                    a If the approach is too high, lower the nose and reduce power
                    b If the approach is too low, add power and raise the nose
                    c Stay on airspeed

        iii. The Angle of Descent
            a. Aiming Points
                - The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
                - Select a point in front of the point of intended touchdown
                    a Approximately 400 to 500' in front of touchdown to allow for the airplane's float
                        1. This is equal to 2 to 2½ stripes prior to your intended touchdown point
                        2. This point will vary based on the aircraft, configuration, weight, and wind conditions.
                - Keep the aiming point steady on the wind screen

a. To a pilot moving straight ahead toward an object, the aiming point appears to be stationary, it does not move.
b. If the point begins to move up on the windscreen the airplane is getting too low
    1. Add power and raise the nose (maintain airspeed – the same airspeed with a higher power setting will result in a slower descent or climb)
c. If the point begins to move down on the windscreen the airplane is getting too high
    1. Reduce power and lower the nose (maintain airspeed – the same airspeed with a lower power setting will result in a steeper descent)
d. Small, active corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway
e. Airspeed remains constant throughout the approach

b. The Runway Image
- Too High
    a. The runway will elongate and become narrower
        1. Overhead view of the runway
- Too Low
    a. The runway will shorten and become wider
        1. Flat view of the runway



- On Descent Path
    a. The runway will be between overhead and flat
    b. The runway shape remains the same but grows in size as we approach

iv. Objective of a Stabilized Approach
    a. To select an appropriate touchdown point on the runway, and adjust the glidepath as necessary to roundout at or above the aiming point, providing distance for the flare to touchdown at the landing point

B. Energy Management
i. A stabilized approach is based on well executed energy management
    a. As mentioned above, during the approach to final you are in the region of reverse command; power controls your rate of descent and pitch controls your airspeed
    b. A normal approach is based on a 3-degree glidepath (this translates to 300' per nautical mile). Therefore, you should be 300' above the touchdown zone elevation one mile from touchdown, and 600' two miles from touchdown
        - This should give you a general idea if you're on or off glidepath during the approach (if you're able to recognize your distance from the runway)
        - The ability to recognize a normal, 3-degree approach path comes with practice and experience
    c. Once configured for the approach, set the approximate pitch attitude and power setting for approach speed
        - The more familiar you are with the approximate pitch and power settings, the easier it will be to manage your energy and maintain a stabilized approach
        - Once the approximate pitch and power setting is established, trim the control forces and crosscheck the airspeed, altitude, and glidepath

- Make adjustments to establish yourself on a 3-degree glidepath while maintaining approach speed
    - a Increase power to decrease your rate of descent. A coordinated increase in pitch will be required to maintain approach speed
        1. Increased power without a change in pitch will increase airspeed
    - b Decrease power to increase your rate of descent. A coordinated decrease in pitch will be required to maintain approach speed
        1. Decreased power without a change in pitch will decrease airspeed
    - c The key to stabilized, well managed, approaches is coordinated inputs between pitch and power in order to maintain a 3-degree glidepath to your aiming point at approach speed

d. "Go ugly early"

- Make corrections early. Don't make a gradual correction to the glidepath or centerline of the runway, establishing yourself just prior to touchdown. This is unsafe.
    - a You should be established on glidepath and course by 300'.
        1. This is a technique, but set a personal minimum where you will initiate a go around if you are not stabilized - on glidepath, airspeed, and runway course
- If you realize you are off course (altitude or course), "go ugly early"
    - a Make the necessary correction to reestablish yourself on glidepath and course as early as possible
    - b The earlier you are stable, the safer the approach
        1. Of course, don't be overly aggressive with the aircraft at slow airspeeds near the ground.
    - c For example, if you roll out a quarter to a half mile off centerline don't make a slow adjustment back to centerline, arriving just before touchdown. As soon as you see the mistake, make the required corrections to get established and stabilized early
        1. Yes, the approach will look "ugly early" (you may have to make a considerable correction back to centerline) but it is far safer to be established early than not be stabilized close to the ground

2. Effects of Atmospheric Conditions, Including Wind, on a Go-Around or Rejected Landing

A. Wind

i. A headwind during a go-around decreases the aircraft's groundspeed and increases performance

a. More airflow over the wings and a slower groundspeed mean that the aircraft climbs a greater amount in a given distance

ii. A tailwind on the other hand increases the groundspeed and therefore decreases performance

a. The aircraft has less airflow over the wings and a higher speed over the ground meaning that the it will climb a lower amount over a given distance

B. Density Altitude

i. Density altitude is pressure altitude adjusted for non-standard temperature

ii. Increased density altitude (lower pressure and/or higher temperature) decreases performance whereas decreased density altitude (higher pressure and/or lower temperature) increases performance

iii. During a go around, the lower the density altitude, the better the aircraft's performance and vice versa

3. Wind Correction Techniques on Takeoff/Departure, and Approach/Landing

A. Takeoff

i. If a crosswind is indicated (windsock, ATIS, other direction indicators) full aileron should be held into the crosswind as the roll is started

        a. This raises the aileron on the upwind wing to impose a downward force on the wing counteracting the lifting force of the crosswind and preventing the wing from raising
        b. With the aileron into the wind, the rudder should be used to keep the takeoff path straight
            - Rudder in the direction opposite of the aileron input is required to keep the takeoff path straight
    ii. Gaining Speed
        a. As the forward speed is increased, the crosswind becomes more of a relative headwind and the air moving faster over the flight controls causes them to be more effective, therefore full aileron pressure into the wind should gradually be reduced
            - Some aileron pressure will need to be maintained – It doesn't all go away
                a Don't be mechanical in the use of aileron control, rather sense the need for varying aileron control input through feel for the plane and visual indications
                b Don't use excessive aileron input in the latter stage of the takeoff roll, this can result in a steep bank into the wind at lift-off (putting the wing near the runway surface)
                    1. Slowly reduce aileron pressure as the crosswind becomes more of a relative headwind and the control surfaces become more effective
    iii. Avoid an early lift-off resulting in side-skipping
        a. If the correction is not held properly, a skipping action may result
            - Indicated by a series of very small bounces
        b. Side-skipping imposes severe side stresses on the landing gear and could result in structural failure
    iv. Lift-Off
        a. In a significant crosswind, hold the main gear on the ground longer to ensure a smooth but definite takeoff
            - Leave the ground with more positive control and prevent side loading on the landing gear
        b. It is important that sufficient aileron is held into the wind so that immediately after liftoff the aircraft is side slipping into the wind to counteract drift
            - 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
                a This is acceptable and preferred to side skipping

B. Departure
    i. Once the plane leaves the ground drift correction needs to be maintained
        a. Visually
            - The runway will begin to disappear as the nose pitches upward
            - Maintain the centerline as well as airplane pitch and bank with outside references and instrument indications
        b. At this point the side slip can be removed and the aircraft can be crabbed into the wind
            - This removes the uncoordinated situation and reduces pilot workload
            - Continue to ensure the aircraft travels on course in a crab and doesn't drift

C. Approach
    i. Side Slip
        a. Align the airplane's heading with the centerline of the runway, noting the rate and direction of drift
        b. Promptly apply drift correction
            - Lower the upwind wing
                a Amount of lowering depends on the drift

b. When the wing is lowered, the airplane will turn in that direction, so simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane aligned with the runway

c. 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
   - Increase or decrease bank angle to keep the aircraft aligned with the center of the runway and adjust rudder pressure in order to keep the aircraft's longitudinal axis aligned with/parallel to the centerline of the runway
   - Strong Crosswind
     - a. In the case that it is not possible to maintain the centerline, the wind is too strong to safely land on the particular runway
       1. There is insufficient rudder to maintain a heading with the required bank application
       2. The landing should be made on a more favorable runway

e. Maintain a stabilized approach
   - Same as normal, except with the added side slip
   - Because you are in a slip, drag is increased, more power will be necessary to maintain a given descent rate

D. Landing (continuing the side slip)
   i. Roundout
      a. Generally made like a normal landing approach, but the crosswind correction is continued as necessary to prevent drifting
         - Don't level the wings
           - a. This will result in drifting, which results in side loading the gear

   ii. Touchdown
      a. The touchdown should be made on the upwind main wheel first
         - Maintain crosswind correction to prevent drift

      b. As the momentum decreases, the weight of the airplane will cause the downwind main wheel to gradually settle onto the runway, then the nosewheel

   iii. After Landing Roll
      a. Maintain directional control with rudders
         - With a greater profile behind the main wheels, the airplane will tend to weathervane into the wind

      b. Maintain crosswind control with ailerons
         - Full aileron into the wind
           - a. Keeps the upwind wing from rising
         - As the speed decreases, increasing aileron is going to be necessary

4. Extra Note:

A. Remember a go around is always free

B. If you ever find yourself behind the aircraft, scrambling to make the runway, or uncomfortable with anything, go around
   i. If it doesn't feel right, it probably isn't. Go around and setup for another approach

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Delayed Recognition of the Need for Rejected Landing/Go-Around**
   A. If you're ever in doubt, go around
   B. Unstable Approach Criteria
      i. Stable means on airspeed, glidepath, and runway centerline
         a. *Momentary* deviations from speed, glidepath and centerline are acceptable
      ii. Set limits for airspeed/altitude requirements and an altitude at which if you are outside any of these limits you will go around – no questions asked
         a. For example, ±5 knots and within 50' of altitude within a half mile of the runway (150' AGL)
            - Assuming a 3-degree glidepath, you should be 300' AGL one mile out and 600' AGL 2 miles out, etc. Unless you have ground references at these points, recognizing this will come with experience
            - If you are outside of these tolerances, the approach is unstable and it is time to go around
   C. Set standards for yourself. When you're outside those standards, don't delay the go-around
2. **Delayed Performance of Go-Around at Low Altitude**
   A. Delaying the go-around often stems from two sources:
      i. Landing expectancy
         a. The set anticipatory belief that conditions are not as threatening as they are and that the approach will surely end with a safe landing
      ii. Pride
         a. The mistaken belief that a go around is an admission of failure
      iii. Understand these conditions and don't let them influence your decision to go around
   B. Delaying a go-around at low altitudes can quickly lead to an unsafe situation
      i. The most critical go-around will be one started when very close to the ground. Therefore, the earlier a condition that warrants a go-around is recognized, the safer the go-around/rejected landing will be
   C. As mentioned above, set standards. When you are outside of those standards execute a go around immediately, no questions asked
3. **Improper Application of Power**
   A. Power is your first concern during a go around
      i. Apply full power smoothly and without hesitation
         a. When power is added, anticipate the right rudder inputs required to maintain coordination and adjust elevator pressure as necessary to establish a climb. The aircraft may have a tendency to pitch up rapidly when trimmed for approach and large amounts of power are added – maintain control and retrim the aircraft
   B. Improper power application can result in diminished climb ability and less than maximum performance
      i. Power is integral to quickly and safely getting the aircraft traveling away from the ground. Don't delay!
   C. In addition to power, be sure to establish a climb attitude (if airspeed will allow it), or establish an attitude that will allow a buildup of speed with minimal loss of altitude until a climb airspeed is reached
         a. Raising the nose too early can result in a stall close to the ground
      ii. The application of full power with the aircraft trimmed for the approach (nose up) can result in the aircraft trying to pitch up excessively
         a. Maintain control of the aircraft pitch and 'rough trim' the aircraft to relax the controls until you can trim more precisely
4. **Improper Aircraft Configuration**
   A. Proper Configuration
      i. Flaps first, gear second (if retractable)

a. Landing flaps create more drag than the landing gear, and the gear should remain down until a positive rate of climb is established (in case you make contact with the ground)
b. Follow manufacturer's guidelines for the go around configuration, but you will likely establish the power and pitch for the go around and then retract the flaps or place them in the takeoff position as recommended by the manufacturer
   - Caution must be exercised in retracting the flaps, a sudden retraction of all the flaps could result in a loss of lift causing the aircraft to settle into the ground
c. Gear should be retracted only after the initial or rough trim of the aircraft has been accomplished and it is certain the aircraft will remain airborne

B. Improper configurations can reduce the aircraft's ability to climb or result in touching down with the gear retracted. Follow the manufacturer's recommendations!

5. Collision Hazards

A. Aircraft
   i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
   ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
         - If they are different categories:
            a A balloon has the right of way over any other category
            b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
            c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
            d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
      c. Approaching Head-on
         - Each pilot shall alter course to the right
      d. Overtaking
         - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
      e. Landing
         - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
            a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
         - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
            a Don't take advantage of this rule to cut in front of another aircraft
   iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
    - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
    - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
  a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
  b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
    - This is also more applicable to cruise, but can be used while the pattern, if necessary
  c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
  a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
 i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
  a. Study sectionals and terminal area charts
  b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
  c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
 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
    - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
  b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
 i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
  a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
  b. Become familiar with any obstacles on the approach and departure path
  c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
  d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
  e. NOTAMs are issued on lighted structures experiencing light outages
 ii. Antenna Towers

a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
   - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure

iii. Overhead Wires
   a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
   b. These wires and lines may or may not be lighted
   c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
   a. Ensure proper clearance between the aircraft and obstacle
      - If unsure of clearance, stop until you’re sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

D. Vehicles, Persons, Wildlife, etc.
   i. Be alert for anyone/anything that may cause a hazard
      a. Often times the ATIS/NOTAMs will inform a pilot of potential vehicles and persons that may be working on or around the airport environment
         - Be cautious
         - Initiate a go-around, if required
      b. Wildlife (birds, deer, coyotes, etc.) is common around many airports. Be aware of the potential for wildlife on in and around the airport environment
         - It may be necessary to go-around in the case wildlife is on or approaching the runway. Err on the side of caution

6. Low Altitude Maneuvering

A. Low Altitude Maneuvering
   i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
         - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
   ii. Be aware of, and avoid obstructions on and around the airfield
      a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
      b. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin
   i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
      a. Airspeed
         - Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach.
            a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
         - If you get any indication of a stall at low level, recover from the stall and go around
            a Max, Relax, Roll is a common memory aid for stall recovery
               1. Apply max power

            2. Relax back pressure, and add whatever nose down pressure is necessary to break the stall
            3. And roll wings level
    b. Cross Controlled Stall
        - Here's a situation that will lead to a cross-controlled condition in the pattern:
            a In a descent, the pilot starts the left turn from base to final late, additionally there's an overshooting wind pushing the aircraft past the runway centerline and potentially into the final approach of a parallel runway
            b In order to attempt to fix the problem, the pilot rolls to 30° of bank, knowing that is the limit for safe bank in the pattern, but 30° of bank is not enough to line aircraft up with the centerline, an overshoot is inevitable
                1. In order to correct, and avoid the parallel runway's final approach area, the pilot adds left rudder (trying to force the airplane around the corner and avoid the overshoot), while maintaining 30° of bank
                    a. The left rudder pushes the nose around, and also increases lift on the right wing (the yaw swings the right wing around, moving it faster than the left, increasing lift)
                    b. As lift increases on the right wing, the aircraft rolls left, the pilot applies right aileron to maintain 30° of bank
                        i. The aircraft is now in an uncoordinated cross-controlled situation - Left rudder and right aileron
            c This can quickly lead to a very dangerous cross-controlled stall. One in which the aircraft may roll over (almost, if not fully inverted). The natural reaction of rolling in the opposite direction only intensifies the stall. This is likely unrecoverable at low altitudes. Maintain coordination!
ii. Spin
    a. A spin is a result of a stall + yaw
        - The primary cause of a spin is stalling the aircraft in an uncoordinated turn
    b. Prevention
        - Maintain coordination
        - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
        - Stop the maneuver 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 gently raise the nose, being careful not to stall the aircraft again
    d. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

C. 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. The majority of CFIT incidents occur during final approach and landing
        b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight

c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range

iii. Recommendations:

a. Non-instrument rated VFR pilots should not attempt to fly in IMC.

b. Know and fly above minimum published safe altitudes.

- VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.

d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.

e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.

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 outside the United States or 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. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. In the descent, approach, traffic pattern, and landing, the pilot's attention should be focused on flying the aircraft, scanning for traffic, and preparing for/making the approach and landing.

ii. At a controlled field, listen to ATC's instructions

a. Also pay attention to what the controller is saying to other traffic to build a picture of the traffic in and around the airport and where you expect them to be

iii. At an uncontrolled field, monitor the CTAF frequency (also to build a picture of the traffic in and around the airfield)

iv. Fly first!

a. Aviate, Navigate, Communicate

v. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

vi. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)

a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the traffic pattern. A loss of situational awareness can lead to unsafe situations, mishaps as well as incursions on the ground and in the air

i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio

ii. There is no place for distractions in the traffic pattern and in the runway environment

iii. Maintain situational awareness

a. If it is lost, admit it. If there's another pilot, let him or her 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 and altitude) and then solve the problem

C. Task Management

i. A go around can occur at a very busy, critical portion of the approach to landing

a. Your first job is always to fly the aircraft
    - Once the aircraft is safely configured and pointed away from the ground, then you can continue with other requirements (radio calls, etc.)
    - If necessary, tell the tower to standby (don't crash trying to make a radio call)

ii. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls at an uncontrolled field
   a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
   b. Safety is your number one priority
      - Aviate, Navigate, Communicate

iii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
   a. Checklists are extremely helpful in properly managing tasks

iv. Recognize when you are getting behind the aircraft, and find a way to catch up
   a. If more time is needed, go around, find somewhere to hold/circle, or slow down
   b. Ask for assistance, if possible
   c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Make a timely decision to discontinue the approach to landing.
4. Apply takeoff power immediately and transition to climb pitch attitude for V_X or V_Y as appropriate +10/-5 knots.
5. Configure the aircraft after a positive rate of climb has been verified or in accordance with airplane manufacturer's instructions.
6. Maneuver to the side of the runway/landing area when necessary to clear and avoid conflicting traffic.
7. Maintain V_Y +10/-5 knots to a safe maneuvering altitude.
8. Maintain directional control and proper wind-drift correction throughout the climb.

PERFORMANCE MANEUVERS

V.A. Steep Turns

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Purpose of Steep Turns**
   A. The purpose of the maneuver is to develop the smoothness, coordination, orientation, division of attention, and control techniques necessary for the execution of maximum performance turns when the aircraft is near its performance limitations
2. **Coordinated and Uncoordinated Flight**
   A. General
      i. In order to maintain coordinated flight during a steep turn rudder must be input in the direction of the turn. The amount of rudder varies based on airspeed, the angle of attack, and the amount of bank
   B. Adverse Yaw
      i. In a turn, the downward deflected aileron (the high/raised wing in the turn) produces more lift, and therefore more drag
         a. This added drag attempts to yaw the airplane's nose in the direction of the raised wing (opposite the direction of the turn)
      ii. The rudder is used to counteract adverse yaw
         a. The amount of rudder control required increases at low airspeeds, high angles of attack, and with large aileron deflections
            - With lower airspeeds, the vertical stabilizer/rudder becomes less effective, therefore magnifying the control problems associated with adverse yaw
   C. Torque Effect
      i. The internal engine parts and propeller are revolving in one direction; an equal force is trying to rotate the airplane in the opposite direction
         a. Newton's 3rd Law – every action has an equal and opposite reaction
         b. This force acts around the longitudinal axis, tending to make the airplane roll to the left
      ii. Left Turn
         a. Due to the torque effect, there is a tendency to develop a skid
            - May need less left rudder to maintain coordinated flight
               a In a left turn, adverse yaw acts in concert with other yawing moments to exaggerate the skid
      iii. Right Turn
         a. Torque effect results in a tendency to develop a slip
            - May need to add right rudder to maintain coordinated flight
               a In a right turn, adverse yaw acts in opposition to other yawing moments to minimize the slipping tendency
3. **Overbanking Tendencies**
   A. Over-banking tendency is the result of the aircraft being banked steeply enough to reach a condition of negative static stability about the longitudinal axis
      i. Static Stability refers to the initial response of a system to a disturbance
      ii. Static stability can be positive, neutral, or negative

a. Static Stability is the tendency of the aircraft, once displaced, to try to return to the stable condition as it was before being disturbed
   - In a shallow turn, the airplane displays positive static stability
     a Initially tries to return to a wings level attitude
   - In a medium banked turn, the airplane shows neutral stability
     a The airplane will remain in the bank
   - In a steep turn, the airplane demonstrates negative static stability
     a The airplane will try to steepen the bank rather than remain stable
     b This is the over-banking tendency (more info below)

B. Why Overbanking Occurs
   i. As the radius of the turn becomes smaller, a significant difference develops between the speed of the inside wing and the speed of the outside wing
      a. The wing on the outside of the turn travels a longer circuit than the inside wing, yet both complete their respective circuits in the same length of time
         - Therefore, the outside wing must travel faster than the inside wing; as a result, it develops more lift
         - A slight differential between the lift of the inside and outside wings tends to further increase the bank
      b. As a shallow bank changes to a medium bank and the radius of turn decreases, the airspeed of the wing on the outside of the turn increases in relation to the inside wing, but the force created exactly balances the force of the inherent lateral stability of the airplane so that, at a given speed, no aileron pressure is required to maintain that bank
      c. As the radius decreases further when the bank progresses form a medium bank to a steep bank, the lift differential overbalances the lateral stability, and counteractive pressure on the ailerons is necessary to keep the bank from steepening the turn
         - This is the case in a steep turn - in a turn to the left, some right aileron is required to hold the desired bank angle and vice versa

4. Maneuvering Speed (V_A), Including Impact of Weight Changes

A. 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)
   i. 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

B. Weight Changes (Bold Method Video)
   i. V_A increases with increased weight and V_A decreases as weight is decreased
      a. This means the aircraft can maneuver at higher airspeeds when heavy
   ii. Example:
      a. Imagine an aircraft flying straight-and-level at V_A and at max gross weight (V_A is certified at max gross weight)
         - If the pilot were to pitch up excessively the aircraft's angle of attack increases, but right when you reach the limit load factor (3.8 G's for a Normal rated aircraft) the aircraft will reach the critical angle of attack, stall, and return to 1G flight. The aircraft doesn't exceed its structural limitation of 3.8 G's and therefore doesn't break
      b. Now consider the same aircraft (still straight-and-level, still at V_A), but at a lighter weight
         - To maintain level flight, the aircraft now flies at a lower angle of attack. Because of this there is now a greater distance between the aircraft's angle of attack and the critical angle of attack. When the pilot pitches up excessively the aircraft will reach the limit load factor

(3.8 G's) prior to reaching the critical angle of attack, and the aircraft will break before it stalls.

a For this reason, decreases in weight result in lower maneuvering speed. The Bold Method video linked above does a great job explaining this

iii. Since VA 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:

a. $VA\ (at \max gross\ weight) \times \sqrt{Actual\ Gross\ Weight\ \div Max\ Gross\ Weight}$

C. Perform all maneuvers, steep turns included, at or below V_A

i. Keep in mind that as you roll into the turn, the additional lift required to maintain altitude through the turn results in increased drag. Increased power is necessary to maintain a constant airspeed throughout the turn

a. Keep the airspeed in your crosscheck, too much speed can put the aircraft above V_A, and too little can put the aircraft close to a stall

b. When rolling out of the turn and decreasing back pressure, reduce power in order to avoid accelerating as drag is reduced

5. Accelerated Stalls

A. Basically…

i. A stall occurs when the smooth airflow over the wing is disrupted and lift decreases rapidly

a. This is caused when the wing exceeds its critical angle of attack (AOA)

b. This can occur at any airspeed, in any attitude, with any power setting

B. More Specifically…

i. When the AOA is increased to approximately 15°-20° (usually 18°) the air can't follow the upper curvature of the wing

a. This is the critical AOA

ii. As the critical AOA is approached, the air begins separating from the rear of the upper wing surface

a. As the AOA is further increased, the airstream is forced to flow straight back

- This causes a swirling/burbling of air attempting to flow over the upper surface

b. When the critical AOA is reached, the turbulent airflow spreads over the entire upper wing

- This results in a sudden increase in pressure on the upper surface and a decrease in lift

a Due to the loss of lift and the increase in form drag (large area of the wing/fuselage is exposed to the turbulent airstream) the remaining lift can't support the plane and the wing stalls

C. Specific to an Accelerated Stall

i. At the same gross weight, configuration, and power setting, 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 (steep turns, pull-ups, or other abrupt maneuvers)

a. For example, in a steep turn if excessive back pressure is added the aircraft can stall at speeds well above the indicated stall speed

ii. An aircraft will stall during a coordinated steep turn exactly as it does from straight flight, except that the pitching and rolling actions tend to be more sudden

D. Recovery

i. Promptly release sufficient back elevator pressure, increase power, and return to straight and level, coordinated flight

6. Controlling Rate and Radius of Turn

A. Rate of Turn

   i. The rate of turn is the number of degrees per second the aircraft is turning. Of course, the higher the degrees per second the higher the rate of turn and vice versa
   ii. Rate of turn is affected by both the bank angle and airspeed
      a. As bank angle increases, so does the rate of turn
      b. As airspeed increases, the rate of turn decreases
      c. Therefore, the higher the bank angle and the slower the airspeed, the higher the rate of turn
B. Radius of Turn
   i. The radius of a turn describes the size of circle an aircraft would fly during a turn
      a. The radius is a measurement taken from the center of the circle to any point on the circle
   ii. Radius of turn is also affected by both the bank angle and airspeed
      a. As bank angle increases, the radius of turn decreases
      b. As airspeed increases, the radius of turn increases
      c. Therefore, the higher the bank angle and the slower the airspeed, the smaller the radius of turn

7. **Effect of Bank Angle on Stalls** (No longer included in the ACS)
   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 steeper the bank angle, the greater the horizontal lift and the less the vertical lift
            - This is why you must increase back pressure as you increase bank in order to maintain altitude (the vertical lift that is lost in a turn must be compensated for)
   B. Load Factors
      i. High load factors are imposed on an aircraft as the bank is increased beyond 45°
         a. At a 60° bank, a load factor of 2 G's is imposed on the aircraft structure
         b. At a 70° bank, a load factor of approximately 3 G's is placed on the aircraft
            - Most general aviation airplanes are stressed for approximately 3.8 G's
      ii. 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
         a. EX: 60° of bank will always produce 2 G's, irrespective of airspeed, aircraft, power setting, etc.
      iii. Increases in the load factor increase the stalling speed at a significant rate
         a. Stalling speed increases at the square root of the load factor
            - For example, a plane that stalls at 60 knots in level flight will stall at nearly 85 knots in a 60° bank
      iv. Understanding/observing this fact is an indispensable safety precaution for the performance of all maneuvers requiring turns
         a. In general, the higher the bank angle, the higher the stall speed
8. **Altitude Control at Various Airspeeds** (No longer included in the ACS)
   A. As discussed above, as an aircraft is banked, lift is divided into a vertical and horizontal component
      i. The more bank, the greater the horizontal component and therefore the smaller the vertical component.
      ii. The decreasing vertical component must be compensated for to maintain altitude. Therefore, the higher the bank angle, the greater the back-elevator pressure required to maintain altitude
         a. Steep turns (high angle of bank) will require relatively large amounts of back pressure to maintain altitude
   B. Lift increases and decreases with airspeed
      i. i.e., a higher airspeed equates to more lift and vice versa (other factors remaining constant)
      ii. If you enter a steep turn at a high airspeed, less back pressure (a smaller change in pitch attitude) will be required to maintain altitude during the turn than at a lower airspeed

C. Trim can be a helpful tool to maintain altitude during a turn. At high bank angles, the back-elevator pressure required can be heavy and maintaining it overtime can be taxing.
    i. If desired, input nose-up trim during the roll into the turn in order to relieve some of the back-pressure requirements during the turn
    ii. Be careful to remove the trim during the roll-out in order to prevent excessive forward pressure and maintain altitude
D. Technique: Know the approximate pitch attitude to maintain level flight in a steep turn at a normal airspeed and make small adjustments from there.
    i. Crosscheck the instruments to ensure the desired altitude is maintained

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Divide Attention Between Airplane Control and Orientation
  A. Establish and maintain a crosscheck focusing primarily on visual references outside of the aircraft as well as short checks inside for airspeed, altitude, etc.
  B. Steep turns can be disorienting. A crosscheck based on outside visual references and supplemented with inside instrument indications allows the pilot to divide attention between controlling the aircraft and the orientation of the aircraft
    i. Orientation of the aircraft does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (other airports, aircraft, etc.)
  C. Always divide your attention, in the case of an unsafe situation or unsafe aircraft orientation stop the maneuver and fix the problem. Safety always comes first.

2. Collision Hazards
  A. Aircraft
    i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
    ii. Before starting the steep turn, the pilot should ensure that the area is clear of other traffic since the rate of turn will be quite rapid
      a. Use clearing turns to clear the area laterally and vertically
      b. During the turn, continue to clear in the direction of turn to ensure the area remains clear
    iii. 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 at approximately the same altitude (except head on), the aircraft to the other’s right has the right-of-way.
        - If they are different categories:
          a A balloon has the right of way over any other category
          b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
          c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft

                - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
        c. Approaching Head-on
            - Each pilot shall alter course to the right
        d. Overtaking
            - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
        e. Landing
            - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
                - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
            - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
                - a Don't take advantage of this rule to cut in front of another aircraft
    iv. Minimum Safe Altitudes (FAR 91.119)
        a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
            - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
            - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure
    v. Scanning
        a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
            - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection
B. Terrain
    i. Be aware of terrain in the vicinity of the aircraft
        a. Be familiar with sectionals and terminal area charts
            - Know appropriate altitudes to remain clear of the terrain, especially in a steep turn where the turn is happening quickly
        b. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
    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
            - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
        b. A personal minimum may be to only fly over high terrain during daylight
C. Obstacle and Wire Strike Avoidance
    i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

ii. Steep turns should not be attempted at this altitude. A general rule is to limit bank in the pattern and at low levels to 30-degrees
    a. In the case that a steep turn is necessary, clear in the direction of turn to ensure the aircraft does not come in contact with an obstacle or wire
    b. Also, be familiar with obstacles, towers, and wires in the vicinity of anywhere you will be flying at these altitudes (likely in the pattern)
iii. Antenna Towers
    a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
        - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure

3. Low Altitude Maneuvering

A. Low Altitude Maneuvering
  i. A small problem at high altitude can quickly become a big problem at a low altitude
    a. There is considerably less time to handle any issues at a low altitude
    b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
        - Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)
    c. Keep the aircraft coordinated, do not bank excessively, and be prepared to recover to level flight if necessary

B. Low Altitude Stall/Spin
  i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
  ii. Accelerated Stalls
    a. Begin the steep turn at or below V_A, and gently increase back pressure as you roll into the turn
        - Excessive, abrupt increases in back pressure can lead to an accelerated stall
    b. At the first sign of an accelerated stall recover
        - Max Power
        - Relax the back pressure
        - Roll wings level
        - Return to straight and level coordinated flight

C. Spins
  i. A spin is a result of a stall + yaw
    a. The primary cause of a spin is stalling the aircraft in an uncoordinated turn
  ii. Prevention
    a. Maintain coordination
    b. Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
    c. Stop the maneuver and recover at the first sign of a stall
  iii. Recovery (PARE)
    a. Power - Idle
    b. Ailerons - Neutral
    c. Rudder - Full rudder opposite the spin direction
    d. Elevator - Brisk, positive forward pressure (nose down)
    e. Once the spin has stopped, neutralize the rudders and gently raise the nose, being careful not to stall the aircraft again

iv. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

D. CFIT (Controlled Flight into Terrain)
  i. [AC 61-134](AC 61-134): General Aviation CFIT Awareness
  ii. The solution to combating CFIT accidents starts on the ground
    a. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
    b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
  iii. Recommendations:
    a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
    b. Know and fly above minimum published safe altitudes.
      - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
    c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
    d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
    e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
    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 outside the United States or 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.

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
  i. Distractions should be avoided during steep turns
    a. With the relatively high task saturation associated with a steep turn (bank control, high back pressure, altitude control, coordination, high rate of turn, orientation, etc.) distractions can lead to excessive changes in altitude, loss of orientation, and an inability to clear for other traffic
  ii. Pay attention to the aircraft performance and clearing for traffic
    a. In the case the pilot does become distracted, recognize the problem, admit it, stop the maneuver and start over. Safety first.

B. Failure to Maintain Situational Awareness
  i. Situational awareness can be lost in a steep turn easier than many other maneuvers because of the high rate of turn and higher G forces
    a. Note your entry heading/direction on the heading indicator/compass as well as by a visual outside reference
    b. Divide attention between the instruments and visual references
    c. Always know where you are and where you are going
  ii. In the case of a loss of situational awareness, stop the maneuver, admit the problem, and take action to regain situational awareness

C. Task management

i. A lot of things happen quickly during a steep turn. Along with managing the high rate of turn, changing elevator pressure, and maintaining a specific bank angle the pilot must also maintain a lookout for other traffic and potential hazards
ii. Using outside visual references, rather than focusing on the instruments through the turn allows the pilot to manage the turn (bank angle and pitch attitude) while maintaining awareness of his or her surroundings
iii. Find a crosscheck and be very familiar with visual references in order to safely manage the multiple tasks at hand
iv. If you ever feel unsafe or too far behind the aircraft, stop the maneuver and regain your awareness, begin again when safe.

5. **Failure to Maintain Coordinated Flight**
   A. Coordinated flight not only allows for a more efficiently flow aircraft, but is considerably safer than an uncoordinated aircraft
   B. In a steep turn add rudder in the direction of the turn, and adjust it as necessary based on your crosscheck
   C. See Part 2, above, for more info on coordination in the turn

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Establish the manufacturer's recommended airspeed or, if one is not available, a safe airspeed not to exceed V_A.
3. Roll into a coordinated 360° steep turn with approximately a 45° bank.
4. Perform the Task in the opposite direction, as specified by evaluator.
5. Maintain the entry altitude ±100 feet, airspeed ±10 knots, bank ±5°, and roll out on the entry heading ±10°.

V.B. Ground Reference Maneuvers

References: 14 CFR part 61, Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **The Purpose of Ground Reference Maneuvers**
    A. Ground reference maneuvers and their related factors are used in developing a high degree of pilot skill. The elements and principles involved are applicable to performance of customary pilot operations. They aid in the pilot analyzing the effect of wind and other forces acting on the airplane and in developing a fine control touch, coordination, and the division of attention necessary for accurate and safe maneuvering of the aircraft
    B. Rectangular Course
        i. Maintaining a specific relationship between the airplane and the ground.
        ii. Dividing attention between the flightpath, ground-based references, manipulating the flight controls, and scanning for outside hazards and instrument indications.
        iii. Adjusting the bank angle during turns to correct for groundspeed changes in order to maintain constant radius turns.
        iv. Rolling out from a turn with the required wind correction angle to compensate for any drift cause by the wind.
        v. Establishing and correcting the wind correction angle in order to maintain the track over the ground.
        vi. Preparing the pilot for the airport traffic pattern and subsequent landing pattern practice.
    C. S-Turns Across a Road
        i. Maintaining a specific relationship between the airplane and the ground.
        ii. Dividing attention between the flightpath, ground-based references, manipulating the flight controls, and scanning for outside hazards and instrument indications.
        iii. Adjusting the bank angle during turns to correct for groundspeed changes in order to maintain a constant radius turn—steeper bank angles for higher ground speeds, shallow bank angles for slower groundspeeds.
        iv. Rolling out from a turn with the required wind correction angle to compensate for any drift cause by the wind.
        v. Establishing and correcting the wind correction angle in order to maintain the track over the ground.
        vi. Developing the ability to compensate for drift in quickly changing orientations.
        vii. Arriving at specific points on required headings.
    D. Turns Around a Point
        i. Maintaining a specific relationship between the airplane and the ground.
        ii. Dividing attention between the flightpath, ground-based references, manipulating of the flight controls, and scanning for outside hazards and instrument indications.
        iii. Adjusting the bank angle during turns to correct for groundspeed changes in order to maintain a constant radius turn; steeper bank angles for higher ground speeds, shallow bank angles for slower groundspeeds.
        iv. Improving competency in managing the quickly changing bank angles.
        v. Establishing and adjusting the wind correction angle in order to maintain the track over the ground.
        vi. Developing the ability to compensate for drift in quickly changing orientations.
        vii. Developing further awareness that the radius of a turn is correlated to the bank angle.

2. **Effects of Wind on Ground Track and relation to a Ground Reference Point**
    A. Wind Correction
        i. Whenever there is any crosswind, the plane will have to be crabbed into the wind to maintain a straight track across the ground or a given distance around a point
            a. The amount of crab varies with the strength of the wind and should be adjusted based on visual cues
        ii. During a turn, the amount of bank will vary depending on groundspeed in order to maintain a constant radius around a point
            a. The faster the groundspeed (tailwind), the steeper the bank required to maintain the desired ground track
            b. The slower the groundspeed (headwind), the shallower the bank required to maintain the desired ground track
            c. During turns, to maintain altitude, increase back pressure as necessary
                - Use visual references and the instrument indications
3. **Effects of Bank Angle and Groundspeed on Rate and Radius of Turn**
    A. Rate of Turn
        i. The rate of turn is the number of degrees per second the aircraft is turning. Of course, the higher the degrees per second the higher the rate of turn and vice versa
        ii. Rate of turn is affected by both the bank angle and groundspeed
            a. As bank angle increases, so does the rate of turn
            b. As groundspeed increases, the rate of turn decreases
            c. Therefore, the higher the bank angle and the slower the groundspeed, the higher the rate of turn
    B. Radius of Turn
        i. The radius of a turn describes the size of circle an aircraft would fly during a turn
            a. The radius is a measurement taken from the center of the circle to any point on the circle
        ii. Radius of turn is also affected by both the bank angle and groundspeed
            a. As bank angle increases, the radius of turn decreases
            b. As groundspeed increases, the radius of turn increases
            c. Therefore, the higher the bank angle and the slower the groundspeed, the smaller the radius of turn
4. **The Relationship of the Rectangular Course to the Traffic Pattern**
    A. The rectangular course is designed to be similar to a traffic pattern
    B. The aircraft should be flown parallel to and at a uniform distance, about ¼ to ½ mile, from the boundaries
        i. Not directly above the boundaries since this will not provide useable reference points for turning
        ii. The pilot should be able to see the edges of the rectangle easily
    C. All turns should be started when the aircraft is abeam the corner of the field boundaries
        i. The closer your track is to the boundaries, the steeper the bank necessary at the turning points
            a. Bank should be limited to 45° maximum
    D. Basically, the rectangular course is a representation of the traffic pattern. It includes a downwind, base, upwind and crosswind leg. The pilot flies these legs in order to learn to adjust for changing wind conditions on the different legs, exactly like they would in the pattern

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Failure to Divide Attention Between Airplane Control and Orientation**
    A. Establish and maintain a crosscheck focusing primarily on visual references outside of the aircraft as well as short checks inside for airspeed, altitude, etc.
    B. A crosscheck based on outside visual references and supplemented with inside instrument indications allows the pilot to divide attention between controlling the aircraft and the orientation of the aircraft
        i. Orientation of the aircraft does not just include the bank angle/pitch attitude, but also where you are (airspace, terrain, etc.) and what or who is around you (other airports, aircraft, etc.)
    C. Always divide your attention. In the case of an unsafe situation or unsafe aircraft orientation stop the maneuver and fix the problem. Safety always comes first.
2. **Collision Hazards to Include Other Aircraft, Terrain, Obstacles, and Wires**
    A. Aircraft
        i. Operation Lights On
            a. A voluntary FAA safety program to enhance the see and avoid concept
            b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
        ii. Before starting the maneuver, the pilot should ensure that the area is clear of other traffic
            a. Use clearing turns to clear the area laterally and vertically
            b. During the maneuver, continue to clear in the direction of turn to ensure the area remains clear
        iii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
                - If they are different categories:
                    a A balloon has the right of way over any other category
                    b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
                    c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
                    d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
            c. Approaching Head-on
                - Each pilot shall alter course to the right
            d. Overtaking
                - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
            e. Landing
                - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
                    a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
                - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
                    a Don't take advantage of this rule to cut in front of another aircraft

iv. Minimum Safe Altitudes (FAR 91.119)
    a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
        - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
        - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

v. Scanning
    a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the aircraft
    a. Be familiar with sectionals and terminal area charts
        - Know appropriate altitudes to remain clear of the terrain, especially in a steep turn where the turn is happening quickly
    b. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
        - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Obstacles often exist at the top of hills or mountains (antennas, for example). Be aware of any obstacles near where you will be practicing maneuvers and ensure you are safely above or away from them

ii. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. Ground reference maneuvers should be flow between 600 and 1,000' AGL. Although the aircraft should be above these structures, be familiar with obstacles, towers, and wires in the vicinity

iii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
        - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

3. Low Altitude Maneuvering

A. Low Altitude Maneuvering

i. A small problem at high altitude can quickly become a big problem at a low altitude
    a. There is considerably less time to handle any issues at a low altitude
    b. Therefore, avoid distractions, maintain situational awareness, and fly precisely

- Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)

c. Keep the aircraft coordinated, do not bank excessively, and be prepared to recover to level flight if necessary

B. Low Altitude Stall/Spin
   i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
   ii. At the first sign of a stall recover:
      a. Max Power
      b. Relax the back pressure
      c. Roll wings level
      d. Return to straight and level coordinated flight

C. Spins
   i. A spin is a result of a stall + yaw
      a. The primary cause of a spin is stalling the aircraft in an uncoordinated turn
   ii. Prevention
      a. Maintain coordination
      b. Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
      c. Stop the maneuver and recover at the first sign of a stall
   iii. Recovery (PARE)
      a. Power - Idle
      b. Ailerons - Neutral
      c. Rudder - Full rudder opposite the spin direction
      d. Elevator - Brisk, positive forward pressure (nose down)
      e. Once the spin has stopped, neutralize the rudders and gently raise the nose, being careful not to stall the aircraft again
   iv. Different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

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. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
      b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
   iii. Recommendations:
      a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
      b. Know and fly above minimum published safe altitudes.
         - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
      c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
      d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
      e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
      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 outside the United States or 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.

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. Distractions should be avoided during ground reference maneuvers especially due to the close proximity to the ground
      a. Pay attention to the aircraft performance and clearing for traffic
         - In the case the pilot does become distracted, recognize the problem, admit it, stop the maneuver and start over. Safety first.

B. Failure to Maintain Situational Awareness
   i. Note your entry heading/direction on the heading indicator/compass as well as by a visual outside reference
   ii. Divide attention between the instruments, visual references, and scanning for traffic/obstacles
   iii. Always know where you are and where you are going
   iv. In the case of a loss of situational awareness, stop the maneuver, admit the problem, and take action to regain situational awareness

C. Task management
   i. Attention needs to be divided between handling the aircraft, scanning for other traffic, and communicating with ATC or making radio calls as necessary
      a. No one responsibility should take your full attention for more than a short period
         - Continually move between tasks to ensure everything is being taken care of. Focus the majority of your attention outside the aircraft only returning inside for short periods
      b. Safety is your number one priority
      c. Aviate, Navigate, Communicate
   ii. Always maintain control of the aircraft, especially when maneuvering at the altitudes associated with ground reference maneuvers
      a. Distractions, focused attention, etc. can result in a loss of control of the aircraft
         - At the low altitudes associated with ground reference maneuvers there may not be enough time or altitude to recover
      b. Fly the aircraft first
   iii. Using outside visual references, rather than focusing on the instruments through the turn allows the pilot to manage the maneuver while maintaining awareness of his or her surroundings
   iv. Use a crosscheck and be very familiar with visual references in order to safely manage the multiple tasks at hand
   v. If you ever feel unsafe or too far behind the aircraft, stop the maneuver and regain your awareness, begin again when safe.

5. Failure to Maintain Coordinated Flight

A. Coordinated flight not only allows for a more efficiently flow aircraft, but is considerably safer than an uncoordinated aircraft
   i. The additional drag created by flying uncoordinated results in excess power, more work for the pilot and a less comfortable ride for everyone
   ii. In the case of a stall, uncoordinated flight poses the risk of a spin. This could be unrecoverable at low altitudes.

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Select a suitable ground reference area, line, or point as appropriate.
3. Plan the maneuver:
   - 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
   - S-turns: enter perpendicular to the selected reference line, 600 to 1,000 feet AGL at an appropriate distance from the selected reference area
   - 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
4. Apply adequate wind drift correction during straight and turning flight to maintain a constant ground track around a rectangular reference area, or to maintain a constant radius turn on each side of a selected reference line or point.
5. If performing S-Turns, reverse the turn directly over the selected reference line; if performing turns around a point, complete turns in either direction, as specified by the examiner.
6. Divide attention between airplane control, traffic avoidance and the ground track while maintaining coordinated flight.
7. Maintain altitude ±100 feet; maintain airspeed ±10 knots.

NAVIGATION

VI.A. Pilotage and Dead Reckoning

References: 14 CFR part 61, Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Navigation Charts

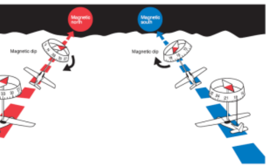
KNOWLEDGE

The applicant demonstrates understanding of:

1. **Pilotage and Dead Reckoning**
   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 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 by computations based on time, airspeed, distance, and direction
      i. The products derived from these, when adjusted by wind speed and velocity, are heading and ground speed
         a. The predicted heading will guide the airplane along the intended path and the ground speed will establish the time to arrive at each checkpoint and destination
   C. Except for flights over water, dead reckoning is usually used with pilotage
      i. Heading and ground speed is constantly monitored and corrected by pilotage as observed from checkpoints
      ii. Ideally, Radio navigation should be added so that a pilot uses all three forms of navigation
         a. Start with dead reckoning and confirm with pilotage and radio navigation
2. **Magnetic Compass Errors**
   A. Variation
      i. Caused by the difference in the locations of the magnetic and geographic north pole
      ii. The north magnetic pole is not collocated with the geographic north pole
         a. The difference between true and magnetic directions
      iii. Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
      iv. Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation
   B. Deviation
      i. Caused by local magnetic fields within the aircraft; different on each heading
      ii. The magnets in a compass align with any magnetic field
         a. Local magnets caused by electrical currents will conflict with the Earth's field
      iii. Deviation varies by heading and is shown on a compass correction card

C. Dip Errors

i. What's Going On



a. The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
- At both poles, the lines are perpendicular to the surface
- Over the equator, the lines are parallel to the surface

b. The magnets align with these fields and near the poles they dip, tilt, the float/card

c. The float is balanced with a small dip compensating weight, so it stays relatively level

ii. Northerly Turning Error

a. Caused by the pull of the vertical component of the Earth's magnetic field

b. When flying on a heading of N, a turn to the E results in:
- The aircraft banking to the right and the compass card tilting to the right
- Then, the vertical component pulls the N seeking end of the compass to the right
  - a The float rotates, causing the card to rotate toward the W (opposite the turn)

c. The same happens when turning to the W; the float rotates to the E (opposite)

d. Remember: When starting a turn from a N heading, the compass lags behind the turn

e. When flying on a heading of S, a turn to the E results in:
- The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)

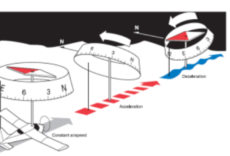
f. When turning to the W, the same happens; the float rotates to the W (same direction)

g. Remember: When starting a turn from a S heading, the compass leads the turn

h. Remember: UNOS - Undershoot North, Overshoot South

D. Acceleration Error

i. The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end



ii. If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N

iii. If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S

iv. When flying on a heading of W, the same things happen

v. Remember: ANDS – Accelerate ➔ North, Decelerate ➔ South

E. Oscillation Error

i. Oscillation is a combination of all the other errors

a. It results in the compass card swinging back and forth around the heading being flown

ii. When setting the HI to the MC, use the average indication

3. Topography

A. Shows the man-made and natural features that would be easily visible to a pilot during flight

i. The man-made features include tall towers, roads, railroad tracks, dams, outdoor theaters, race tracks, bridges, lookout towers, power transmission lines, aerial cables, and coast guard stations

ii. The natural features include lakes, rivers and mountain passes

B. Use the topographic features on the map to assist in maintaining course, and finding waypoints and recognizable points between waypoints, to ensure you're continuing in the right direction

C. Everything you could ever need to know about FAA charts:

i. FAA Aeronautical Chart User's Guide

ii. Everything from contours, lakes, towers, shading relief, lava flows, quarries, craters, and more

4. Route Selection

A. This is discussed in Part 6, briefly in Part 8, as well as in Part 9

B. The route should be based on ease of navigation, navigation aids, terrain, airspace requirements, safety (things like alternates, diversion airfields, fuel stops, training/high traffic areas, parachute jump areas), aircraft performance, etc.

5. Altitude Selection

A. Fly Odd Thousands plus 500' when on a magnetic course between 0 and 179 degrees
   i. For example, 5,500' or 13,500'

B. Fly Even Thousands plus 500' when on a magnetic course between 180 and 359 degrees
   i. For example, 8,500' or 10,500'

C. These rules apply above 3,000' AGL and up to 17,500' MSL (up to Class A airspace)

6. Checkpoint Selection

A. Checkpoints – Recognizable points along your route of flight used to maintain your course
   i. Find checkpoints along the route to ensure you maintain the desired route (don't get lost)
      a. 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
      b. 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
         - Using funneling features or barriers is a good strategy to assist in maintaining course
            a For example, if you can plot your course to stay east of a mountain range and west of a road you can use these features as a funnel, or "road" in the sky to direct your next waypoint or destination

7. Plotting a Course

A. Determining & Drawing a Course
   i. First, draw the route
      a. Route selection and en-route checkpoints are based on a variety of factors as mentioned above in Part 6
         - Select your desired checkpoints and draw a line(s) to connect the waypoints
      b. One your route has been drawn, the top of climb and top of descent need to be plotted
         - These locations will vary based on the altitude to climb, aircraft performance, and ambient conditions and therefore it can be difficult to match them with a checkpoint
            a It's often a good idea to find the top of climb and descent, plot it on your map and find a checkpoint in the area to associate with it (see more below)
   ii. Top of Climb (TOC)
         - Once you have the basic route drawn, 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 info and desired cruising altitude calculate the distance to reach the top of climb
         - Rate of Climb can be calculated in the AFM (ex. 1,000 fpm)
         - Altitude to climb: Cruising altitude – 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 in the climb (TAS adjusted for wind) in order to find 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
iii. Top of Descent (TOD)
    a. 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 (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 * 150 kts/hr. = 13.25 nm
                    a. 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
iv. Fuel Stops
    a. Plane fuel stops based on personal comfort, and at a minimum, on regulatory requirements
        - FAR 91.151 requires that there be enough fuel onboard the airplane to fly to the point of intended landing and, at normal cruise power, to fly for at least
            a 30 min during the day, or 45 min during the night
        - Plan accordingly
v. Unforeseen Events
    a. Once the course is drawn, survey the route of flight
        - Look for available alternate airports along the route
        - Look at the terrain (mountains, swamps, water, etc.) that would have impact if an emergency landing were necessary
        - Mentally prepare for any type of emergency situation and the appropriate action to be taken
        - Also, ensure the route of flight does not penetrate any restricted (if in use) or prohibited areas

B. Determining Heading, Wind Correction Angle, and Speed
i. Heading
    a. Once the route is plotted, find the true course for each leg of the flight plan
        - True Course (TC): Direction of the line connecting two points drawn on the chart and measured clockwise in degrees from True North
            a North is always straight up when measuring true course
            b Use your plotter to find the True Course

b. Adjust True Course for wind in order to get True Heading
c. On the back of the flight computer calculate the Wind Correction Angle, or the number of degrees required to counteract the crosswind effect of the wind and allow the aircraft to maintain the course as shown on the map, and add/subtract it to/from the True Course in order to get your True Heading
    - Add West, subtract East corrections (East is least, West is best is a good memory aid)
d. Finally, adjust the True Heading in order to find Magnetic Heading
    - Magnetic Heading: Magnetic variation is applied to True Heading
        a Using the isogonic lines on the sectional, add or subtract the necessary number of degrees in order to find the magnetic heading required to maintain your course
e. If necessary, get your Compass Heading by adjusting for Deviation with the correction card near the compass of your aircraft

ii. Speed
a. Start by finding the True Airspeed for the trip and record it on your Nav Log
    - Use the chart provided in the aircraft POH
b. When you adjust True Course for wind in order to get True Heading also take into account the headwind/tailwind for each leg and apply it to the True Airspeed (this gives you your groundspeed)
    - On the back of the flight computer calculate the tailwind/headwind based on the winds en-route (or use a calculator, app, etc. to calculate everything)

C. Estimating Time, and Distance
i. Next is the Time and Distance Information
a. Measure the distance of each leg on the sectional
b. Since you now have the Distance and Ground Speed between each point, you can calculate the estimated amount of time for each leg
    - Distance = Rate x Time, so Time = Distance/Rate (or Ground Speed)

D. True Airspeed and Density Altitude
i. True Airspeed is calibrated airspeed corrected for non-standard temperature
ii. True airspeed and Density Altitude
a. Because air density decreases with an increase in altitude, an aircraft has to be flown faster at higher altitudes to cause the same pressure difference between pitot and static pressure
    - Therefore, for a given calibrated airspeed, true airspeed increases as altitude increases

iii. Calculating True Airspeed
a. Use a flight computer, or the charts in the POH
b. A good estimate is to add 2% to the calibrated airspeed for each 1,000’ of altitude
    - For example, a calibrated airspeed of 100 knots at 10,000’ MSL would equate to approximately 120 knots true airspeed

8. Power Setting Selection

A. Using the flight manual performance charts to find the power setting based on the desired fuel burn, cruise speed, and the cruising altitude

9. Planned vs Actual Flight Plan Calculations and Required Corrections

A. Projected weather and actual weather conditions, most specifically, winds, can often differ
i. The greater the difference between actual and projected winds, the greater the difference between the planned and actual flight
a. Corrections must be made to ensure the aircraft stays on the desired course and you do not get lost

    b. If groundspeed changes, the time for each leg will change. Make the required adjustments as you fly so you know when to expect to find waypoints/when to turn

B. Groundspeed
  i. A change in groundspeed will affect the timing between waypoints
    a. Recognize this as early as possible and make the necessary corrections on the flight log in order to correctly identify waypoints
      - Continuing without making corrections can result in missed waypoints and worst case, getting lost
    b. Pay attention to your location and the time crossing each waypoint
      - The timing will often be off be a little bit, due to variations in the winds and power settings/airspeed
      - Calculate your actual groundspeed at each waypoint Rate = Distance/Time
        a Anticipate the changes to timing between the following waypoints
  ii. Groundspeeds different than planned can make it more difficult to find your checkpoints since the timing is off
    a. This is also an excellent reason to pick easily recognizable waypoints that you can find even if the timing happens to be off

C. Course
  i. A difference between projected and actual wind direction can result in a change of groundspeed as well as a change in heading
    a. Use techniques such as bracketing to ensure you remain on course
      - If possible, select features that make useful boundaries or brackets on each side of the course
        a For example, highways, rivers, railroads, and mountains
          1. Brackets help prevent drifting too far off course
          2. Recognize the necessary changes in heading to maintain your track
      - Recognize the different wind direction, adjust your heading and apply these changes as necessary to the following legs
  ii. Additionally, weather or other unexpected situations (airspace closures, etc.) can result in a change of the flight planned route
    a. In the case the route changes or you have to diver to an alternate, corrections will have to be made, literally "on the fly"
    b. Plot the new course, and get an estimate of the magnetic heading required
      - Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance
        a Use your thumb to estimate distance
          1. Using the scale on your map, figure out approximately how far from the fingertip of your thumb (toward the knuckle) 10 nm is
          2. In the case of a diversion use your thumb to quickly measure the number of 10 nm increments to the alternate airport
          3. This will provide a rough distance estimate for quicker, less stressful time and fuel calculations
        b Use a compass rose, airway or any other reference to determine the approximate new heading

D. Fuel Consumption
  i. Use your flight log to monitor the expected fuel en route at each checkpoint and the actual fuel at each checkpoint

a. If you notice fuel consumption is different than planned, recalculate your flight plan based on the new fuel burn
    - If you will not have enough fuel to safely reach your destination, it's time to divert to an alternate
    - If you are getting a better fuel burn than planned, of course you're fine to continue

E. Checkpoints
  i. Never place complete reliance on any single checkpoint – if one is missed, look for the next one while maintaining the calculated heading
  ii. If confused, hold the planned heading and make the next turn based on time
    a. It is easy to become lost if the pilot guesses at when to turn
  iii. Remember that the scale of a sectional chart is 1" to 6.86 NM
    a. If you're checkpoint is a half inch off the course line, you should be looking 3-4 NMs away

F. GPS
  i. It adjusts everything for you, follow it
  ii. Know how to use it

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Collision Hazards, to Include Aircraft, Terrain, Obstacles, and Wires

A. Aircraft
  i. Operation Lights On
    a. A voluntary FAA safety program to enhance the see and avoid concept
    b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
  ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
      - If they are different categories:
        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    c. Approaching Head-on
      - Each pilot shall alter course to the right
    d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    e. Landing

- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
    - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
    - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Cruise Altitude
   a. Even thousands plus 500' when flying a magnetic course between 180 and 359 degrees
   b. Odd thousands plus 500' when flying a magnetic course between 0 and 179 degrees

v. Clearing Procedures
   a. Before Takeoff: Scan the runway and final approach for other traffic
   b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   c. During cruise use the scanning techniques below, and if necessary, use gentle banks to search for other traffic

vi. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

vii. High Traffic Areas
   a. Flying on or near airways (especially around navaids where multiple airways converge) can draw a lot of traffic, be vigilant in looking for other aircraft

B. Terrain

i. Be aware of terrain en route, and any terrain that could cause a hazard during the climb or descent into the airfield
   a. Study sectionals and terminal area charts
   b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
   c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
      - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

        b. A personal minimum may be to only fly over high terrain during daylight
    C. Obstacle and Wire Strike Avoidance
        i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
            a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb/descent
            b. Become familiar with any obstacles on the arrival and departure paths
            c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
            d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
            e. NOTAMs are issued on lighted structures experiencing light outages
        ii. Antenna Towers
            a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
                - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
        iii. Overhead Wires
            a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
            b. These wires and lines may or may not be lighted
            c. Be extremely vigilant on takeoff and landing
        iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
            a. Ensure proper clearance between the aircraft and obstacle
                - If unsure of clearance, stop until you're sure it is safe to pass
        v. If necessary, radio ground to inform them of your intentions or ask for assistance

2. **Distractions, Loss of Situational Awareness, and/or Improper Task Management**
    A. Distractions
        i. Fly first!
            a. Aviate, Navigate, Communicate
            b. The pilot, especially in the case of pilotage and dead reckoning, can easily be distracted from flying the aircraft by reading the chart, looking for waypoints, figuring out their location, etc.
                - Be sure to divide time between the aircraft and the other tasks
                - Use automation, if available to reduce the pilot's workload
                    a This in no way alleviates the pilot's responsibility of monitoring the automation and ensure the aircraft is still flying as desired
        ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
        iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
            a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the current phase of flight
    B. Situational Awareness
        i. A loss of situational awareness is considerably more difficult to regain in a stressful, busy situation such as this
        ii. Ways to Maintain Situational Awareness
            a. Verify all programming

b. Check the flight routing
c. Verify waypoints
d. Make us of all onboard navigation equipment (for example, backup the GPS with a VOR)
e. Match the use of the automated system with pilot proficiency
f. Plan a realistic flight route to maintain situational awareness

C. Task Management
  i. Attention needs to be divided between handling the aircraft, scanning for other traffic, communicating with ATC, and navigating to your destination
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
      - Focusing too much attention on any one task (i.e., reading the map) can result in the others being neglected
        a Results in getting lost, off altitude, improper fuel settings, etc.
    b. It is easy to get drawn into a map or looking intently for a checkpoint
      - Always stop to give attention to flying the aircraft (altitude, airspeed, power settings, etc.) and scanning for other traffic
  ii. Safety is your number one priority
  iii. Aviate, Navigate, Communicate

SKILLS

The applicant demonstrates the ability to:

1. Prepare and use a flight log.
2. Navigate by pilotage.
3. Navigate by means of pre-computed headings, groundspeeds, and elapsed time.
4. Demonstrate use of the magnetic direction indicator in navigation, to include turns to headings.
5. Verify position within three nautical miles of the flight-planned route.
6. Arrive at the en route checkpoints within five minutes of the initial or revised estimated time of arrival and provide a destination estimate.
7. Maintain the selected altitude, ±200 feet and headings, ±15°.:

VI.B. Navigation Systems and Radar Services

References: Risk Management Handbook (FAA-H-8083-2), Airplane Flying Handbook (FAA-H-8083-3), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), Advanced Avionics Handbook (FAA-H-8083-6), AIM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Ground Based Navigation**
   - A. VOR/VORTAC (Very High Frequency Omnidirectional Range)
     - i. Three types of VORS
       - a. VOR – The VOR by itself, provides magnetic bearing information to and from the station
       - b. VOR/DME – When DME (Distance Measuring Equipment) is also installed with the VOR
       - c. VORTAC – When military tactical air navigations (TACAN) equipment is installed with a VOR
         - DME is always an integral part of a VORTAC
     - ii. 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 distance the radials are projected depends on the power output of the transmitter
       - c. The radials projected are referenced to magnetic north
         - Thus, a radial is defined as a line of magnetic bearing extending outward from the VOR station
         - The accuracy of course alignment with radials is considered to be excellent (within ± 1°)
       - d. VOR ground stations transmit within a VHF frequency band of 108.0 – 117.95 MHz
         - Because the equipment is VHF, the signals transmitted are subject to line-of-sight restrictions
           - a Therefore, range varies in direct proportion to the altitude of the receiving equipment
       - e. VORs are classed according to operational use in 3 classes with varying normal useful ranges:
         - T (Terminal); L (Low Altitude); H (High Altitude)
     - iii. VOR Checks
       - a. The best assurance of maintaining an accurate VOR receiver is periodic checks and calibrations
         - Not a regulation for VFR flight
       - b. Checks (checkpoints are listed in the Chart Supplement)
         - FAA VOR Test Facility (VOT)
         - Certified Airborne Checkpoints
         - Certified Ground Checkpoints located on airport surfaces
         - Dual VOR check
       - c. Verifies the VOR radials the equipment receives are aligned with the radials the station transmits
       - d. IFR tolerances required are ± 4° for ground checks and ± 6° for airborne checks
     - iv. Using the VOR
       - a. Identifying It
         - Station can be identified by its Morse code identification or a voice stating the name and VOR
         - If the VOR is out of service, the coded identification is removed and not transmitted

        - a It should not be used for navigation
    - VOR receivers have an alarm flag to indicate when signal strength is inadequate
        - a The plane is either too far or too low and is out of the line-of-sight of the transmitting signal
  - b. There are 2 required components for VOR radio navigation
    - The ground transmitter and the receiver
        - a The ground transmitter is at a specific position on the ground and transmits on an assigned frequency
        - b The airplane equipment includes the receiver with a tuning device and a VOR instrument
            1. The navigation instrument consists of:
                - a. An OBS (Omni bearing Selector), referred to as the course selector
                - b. A CDI (Course Deviation Indicator) Needle
                - c. A To/From Indicator
    - The course selector is an azimuth dial that is rotated to select a radial
        - a In addition, the magnetic course TO or FROM the station can be determined
    - When the OBS is rotated, the CDI moves to show the position of the radial relative to the plane
    - If OBS is rotated to center the CDI, the radial (magnetic course FROM the station) or its reciprocal (magnetic course TO the station) can be found
    - The CDI will also move to the right or left if the airplane is not on the selected radial
  - c. TO and FROM
    - By centering the needle, either the course "FROM" or "TO" the station will be indicated
        - a If the flag displays "TO," and the course is flown, the airplane will fly to the station
            1. The To flag will be displayed ± 90^{o} of the radial you are currently on
            2. EX: If you are on the 090^{o} radial, the 360^{o}-180^{o} radials will indicate a To flag, the other half of the circle will indicate From
        - b If "FROM" is displayed and the course shown followed, the plane flies away from the station
- v. Tracking with VOR
  - a. Tune the VOR frequency and check the identifiers to verify the desired VOR is being received
  - b. Rotate the OBS to center the CDI with a "TO" indication
    - If centered with a "FROM" indication, rotate 180^{o}
        - a From indicates the radial we are on, TO indicates TO the station
  - c. Turn to the heading indicated on the VOR azimuth dial or course selector
    - This will track directly to the station in a no wind situation
  - d. If there is a crosswind, and heading is maintained, you will drift off course
    - If the crosswind is from the right, the airplane will drift to the left of course
        - a The CDI will gradually move right
    - To return to the desired radial, the heading must be altered to the right
        - a As the plane returns, the needle will move back to the center
    - When centered, the airplane is on the selected course, now it must be crabbed into the wind (right of course)
        - a This will establish wind correction (the amount necessary will depend on the wind strength)
            1. Trial and error will establish the necessary heading to maintain the desired track

2. If you have a GPS, use the aircraft track to determine when the aircraft is tracking the desired course (this eliminates the trial and error)

e. Upon arriving, and passing the VOR station, the "TO" indication will change to a "FROM" indication
- Generally, the same procedures apply for tracking outbound as inbound
  - a If the intent is to continue on the same heading the course selector shouldn't be changed
  - b If tracking outbound on a different course, the new course must be set into the selector
    1. Turn to intercept this course and track the same as previously discussed

f. Reverse Sensing
- 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)
  - a If the plane drifts to the right of course, the needle will move right, or point away from the radial
- And vice versa (from a station with a TO indication and opposite drift indications)

vi. VOR Tips
a. Positively identify the station by its code or voice identification
b. Remember, VOR signals are line-of-sight
c. When navigating TO, determine the inbound course and use it (Don't reset the course, correct for drift)
d. When flying TO a station always fly the selected course with a TO indication
e. When flying FROM a station always fly the selected course with a FROM indication

B. ADF (Automatic Direction Finder)

i. The NDB is a ground-based radio transmitter that transmits radio energy in all directions
a. The ADF, when used with an NDB, determines the bearing from the aircraft to the station

ii. The ADF needle points to the NDB ground station to determine the relative bearing
a. Relative Bearing: The number of degrees measured clockwise between the heading of the aircraft and the direction from which the bearing is taken

iii. Magnetic Heading + Relative Bearing = Magnetic Bearing
a. Mary Had + Roast Beef= Marry Barfed
b. Magnetic Heading: The direction an aircraft is pointed with respect to magnetic North
c. Magnetic Bearing: The direction to or from a radio transmitting station measured relative to magnetic North
d. NDB Components
- The ground equipment, the NDB
- The aircraft must be in operational range of the NDB
  - a Depends on the strength of the station

e. ADF Components
1. Tuner and Display (indicator)
- Indicator Instrument
  - a 3 kinds: Fixed card ADF, Movable Card ADF, or the RMI
  - b Fixed Card ADF
    1. Always indicates 0 at the top and the needle indicates RB to the station
  - c Movable Card ADF
    1. Rotates to allow the current heading to be at the top of the instrument
       a. This allows the head of the needle to indicate the MB to the station
       b. The tail indicates MB from the station

d RMI
   1. Automatically rotates the azimuth card to represent aircraft heading
   2. Has 2 needles which can be used for nav info from either the ADF or VOR receivers
   3. When the ADF is driving the needle, the head indicates MB TO the station tuned
      a. The tail is the MB FROM the station tuned
   4. With the VOR driving, the needle shows location radially with respect to the station
      a. The needle points to the bearing TO the station
      b. The tail points to the radial of the VOR the aircraft is currently on/crossing

f. Using the NDB
   - Orientation
     a The ADF needle points TO the station, regardless of heading or position
        1. Relative bearing indicated thus is the angular relationship between heading and the station
           a. Measured clockwise from the nose of the aircraft
     b Visualize the ADF dial in terms of the longitudinal axis
        1. When the needle points to 0^{o}, the nose points directly to the station
        2. With the pointer on 210^{o}, the station is 30^{o} to the left of the tail
        3. With the pointed on 090^{o}, the station is off the right wingtip
        4. The relative bearing itself does not indicate position
     c The relative bearing must be related to aircraft heading to determine direction TO/FROM

2. Satellite Based Navigation

i. Satellite based navigation systems include
   a. GPS (Global Positioning System), WAAS (Wide Area Augmentation System), LAAS (Local…)

ii. GPS
   a. The GPS system is composed of 3 major elements
      - The Space Segment
        a Composed of a constellation of 24 satellites approximately 11,000 NM above the earth
           1. Arranged so at any time, 5 are in view to any receiver (4 are necessary for operation)
           2. Each satellite orbits the Earth in approximately 12 hours
           3. Equipped with highly stable atomic clocks and transmit a unique code/nav message
        b The satellites broadcast in the UHF range (so they are virtually unaffected by weather)
           1. 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
      - The Control Segment
        a Consists of a master control station, 5 monitoring stations, and 3 ground antennas
        b The monitoring stations and ground antennas are distributed around the earth to allow continual monitoring and communications with satellites
           1. Nav message updates are uplinked as satellites pass over the ground antennas
      - The User Segment
        a Consists of all components associated with the GPS receiver
           1. Range from portable, hand-held receivers to permanently installed
        b The receiver utilizes the signals from the satellites to provide:
           1. Positioning, velocity, and precise timing to the user
   b. Solving for Location
      - The receiver utilizes the signals of at least 4 of the best positioned satellites to yield a 3D fix
        a 3D - Latitude, longitude, and altitude

    b Using distance/position info from the satellite, the receiver calculates its location

c. Navigating
   - VFR navigation with GPS can be as simple as selecting a destination and tracking the course
   - GPS Tracking
     a Course deviation is linear, there is no increase in sensitivity closer to waypoints
   - It can be very tempting to rely exclusively on GPS, but never rely on one means of navigation

d. Database
   - Ensure a current database when using the GPS for primary navigation
     a An expired database may be missing procedures or include incorrect data
       1. Generally acceptable as an aid to situational awareness when another method is the primary means of navigation

e. Receiver Autonomous Integrity Monitoring (RAIM)
   - RAIM is the GPS receiver's ability to verify the integrity (usability) of the signals received from the GPS constellation
     a Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position
   - RAIM needs a minimum of 5 satellites in view, or 4 satellites and a barometric altimeter baro-aiding to detect an integrity anomaly
     a Some receivers have the ability to isolate and remove a corrupt signal if 6 satellites, (or 5 with baro-aiding) are in view
   - Generally, there are 2 types of RAIM messages
     a One indicates that there are not enough satellites in view to provide RAIM
     b Another indicates that the RAIM has detected a potential error that exceeds the limit required for the current phase of flight
   - Aircraft using GPS navigation equipment under IFR must be equipped with an approved and operation alternate means of navigation appropriate to the route of flight, but active monitoring of the alternative navigation equipment is not required if the GPS receiver uses RAIM for integrity monitoring
     a Active monitoring of navigation equipment is required when the RAIM capability of the GPS equipment is lost though
     b In situations where the loss of RAIM capability is predicted to occur, the flight must rely on other approved equipment, delay departure, or cancel the flight

f. GPS Substitution
   - GPS systems, certified for IFR en route and terminal operations, may be used as a substitute for ADF and DME receivers when conducting the following operations within the NAS:
     a Determining the aircraft position over a DME fix
     b Flying a DME arc
     c Navigation TO/FROM an NDB/Compass Locator
     d Determining the aircraft position over an NDB/compass locator
     e Determining the aircraft position over a fix defined by an NDB/Compass Locator bearing crossing a VOR/LOC course
     f Holding over an NDB/Compass Locator

iii. WAAS

a. Satellite based augmentation system that improves GPS signals for use in precision approaches
   - Designed to improve the accuracy, integrity, and availability of GPS signals
     a The integrity is improved through real-time monitoring of the satellites, the accuracy is improved by providing corrections to the satellites to reduce errors. As a result,

performance improvement is sufficient to enable approach procedures with GPS/WAAS glidepaths

- Basically, it augments the basic GPS satellite constellation with additional ground stations/enhanced info transmitted from geostationary satellites
- Worst case, WAAS accuracy is approximately 25 feet 95% of the time

b. Approach Capabilities

- WAAS receivers support all basic GPS approach functions and provide additional capabilities with the key benefit to generate an electronic glidepath, independent of ground equipment or barometric aiding
  - a This eliminates several problems, such as cold temperature effects, incorrect altimeter setting, or lack of a local altimeter source, and allows approach procedures to be built without the cost of installing ground stations at each airport.
- A new class of approach procedures, which provide vertical guidance requirements for precision approaches, has been developed. These procedures are called Approach with Vertical Guidance (APV) and include approaches such as LNAV/VNAV procedures presently being flown

iv. LAAS

a. A ground-based augmentation system that uses a GPS-reference facility located on or in the vicinity of the airport being serviced

- This facility has a reference receiver that measures GPS satellite pseudo-range and timing and retransmits the signal.
- Aircraft landing at LAAS-equipped airports are able to conduct approaches to Category I level and above for properly equipped aircraft

b. Functions similar to WAAS but relies more on ground stations for signal correction/improvement

- Considered to be less cost effective than WAAS

c. Considered to be capable of handling Category III instrument approaches

3. Radar Assistance to VFR aircraft

A. ATC facilities provide a variety of services to participating VFR aircraft on a workload permitting basis

i. You must be able to communicate with ATC, be within radar coverage and be radar identified

ii. Services provided include:

a. VFR radar traffic advisory service (Flight Following) and safety alerts

b. Vectoring (when requested)

c. Terminal Radar Programs (TRSA) – To separate all participating VFR aircraft and IFR traffic

d. Radar assistance to lost aircraft

e. Class C services include separation between IFR/VFR and sequencing of VFR traffic to the airport

f. Class B services include separation based on IFR, VFR and/or weight and sequencing VFR arrivals

4. Transponder

A. General

i. An electronic device that produces a response when it receives a radio-frequency interrogation

ii. Assists in identifying aircraft on air traffic control radar and in collision avoidance systems

a. A transponder is considered secondary surveillance radar (rather than primary)

- Primary surveillance radar reflects a radio signal off the skin of an aircraft to identify it on a radar screen, and can determine range and bearing (not altitude)
- Secondary surveillance radar (SSR) can provide the aircraft's altitude as well as the aircraft's 4-digit squawk code (depending on the mode in use – see below)

iii. Mode A

        a. When the transponder receives an interrogation, it sends the aircraft’s squawk code
    iv. Mode C
        a. Mode A with Mode C will broadcast both the transponder code and the aircraft’s pressure altitude
    v. Mode S
        a. Mode S transponders broadcast the code, and pressure altitude as well as the aircraft’s call sign and a 24-digit hex code that is registered to the transponder and becomes part of the aircraft’s certificate of registration
        b. The Mode S transponder can transmit this information to ATC, TCAS (Traffic Collision Avoidance System) on other aircraft, and to the ADS-B SSR system
            - ADS-B (Automatic Dependent Surveillance – Broadcast) is an element of the Next-Gen Air Transportation System
            - It is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked
            - ADS–B is "automatic" in that it requires no pilot or external input
            - It is "dependent" in that it depends on data from the aircraft's navigation system

B. Transponder Use Requirements
    i. On the Ground
        a. Operate with the transponder in the altitude mode at all airports, any time the aircraft is positioned on any portion of an airport movement area
    ii. Mode C Requirements
        a. At or above 10,000’ MSL over the 48 contiguous states, excluding the airspace below 2,500’ AGL
        b. Within 30 miles of a Class B airspace primary airport, below 10,000’
        c. Within and above all Class C airspace, up to 10,000’ MSL
        d. Within 10 miles of certain designated airports (excluding airspace that is both outside the Class D surface area and below 1,200’ AGL)
        e. Crossing the ADIZ
    iii. VFR Transponder Operation
        a. Unless otherwise instructed by ATC, set the transponder to 1200
        b. Use Mode C, with altitude reporting activated, if equipped

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Manage Automated Navigation and Autoflight System

A. Before any pilot can master automation, he or she must first know how to fly the aircraft
    i. A safety issue identified by the FAA concerns pilots who apparently develop an unwarranted overreliance on their equipment, believing the equipment compensates for pilot shortcomings
        a. This is not the case as over half of all GA accidents occur in the takeoff or landing phase that does not involve programming a computer to execute

B. Understand the Platform
    i. Read and understand the system’s manuals and adhere to the AFM/POH procedures

C. Automation System Requirements:
    i. Familiarity
        a. Familiarity with all equipment is critical in optimizing safety and efficiency

b. Being unfamiliar adds to the pilot's workload and may contribute to a loss of situational awareness

ii. Respect for Onboard Systems

a. A thorough understanding is essential to gaining the benefits the system can offer

- Understanding leads to respect

iii. Reinforcement of Onboard Suites

a. Practice what you've learned to gain experience; reinforcement yields dividends in the use of automation and reduces workload

iv. Getting Beyond Rote Workmanship

a. The desire is to become competent and know what to do without having to think about what you need to do next

b. Operating with competency and comprehension benefits a pilot when situations become more diverse and tasks increase

v. Understand the Platform

a. Review and understand the different ways systems are used in a particular aircraft

D. Turn it off, if necessary

i. If the automation isn't doing what you intend in flight, turn it off and reset it, or leave it off and fly the plane

ii. A failure to manage the automation can result in the aircraft going in a different direction than intended without the pilot's knowledge

iii. For example, if you intend to fly a GPS or VOR course but the automation remains in a heading or roll mode

E. If it becomes a distraction, especially in the way of flying the aircraft competently and also in the way of communicating either turn it off or ensure it is operating properly

F. Automated Navigation

i. Improper use of automated navigation (whether the autopilot is tracking a GPS, VOR, LOC course, etc.) can lead to unsafe situations

a. Not only can this result in getting lost and a potential unsafe fuel situation, but you could intrude on other aircraft or into other airspace placing lives at risk

ii. Always confirm that the navigation system is properly configured and that the correct settings are used on the automated navigation (autopilot)

G. Autoflight System

i. Improper use of the autoflight system can also result in unsafe situations

a. It is critical you are competent with autoflight systems prior to relying on them in flight

b. Improper use can result in missing altitude level offs, navigating the wrong course, missing course intercepts, etc.

- All of these can put your life, as well as others at risk

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. Fly first!

a. Aviate, Navigate, Communicate

b. The pilot, especially in the case of pilotage and dead reckoning, can easily be distracted from flying the aircraft by reading the chart, looking for waypoints, figuring out their location, etc.

- Be sure to divide time between the aircraft and the other tasks
- Use automation, if available to reduce the pilot's workload
  - a This in no way alleviates the pilot's responsibility of monitoring the automation and ensure the aircraft is still flying as desired

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the current phase of flight
iv. Automation Distractions
    a. What's it doing now/Why's it doing that?
        - Improper use and an improper or insufficient understanding of the system can result in confusing situations where the automation isn't doing what you desire
            a This can be a huge distraction: not only is the aircraft not doing what you intend, but often all of the pilot's attention is directed to the strange behavior resulting in the aircraft doing something unintended, while unmonitored
            b Fix the situation
                1. Reprogram the automation or turn it off and fly the aircraft
    b. Look at all the Buttons/What does this do?
        - Automation systems can be distracting simply from the fact that they have a lot of buttons and there's a lot to learn
            a Learn the system on the ground, fly the aircraft in the air
    c. Match the use of the automated system with pilot proficiency
        - The autopilot can be a great tool to reduce pilot workload as long as the pilot is competent in its operation. Don't let the automation detract from situational awareness

B. Loss of Situational Awareness
i. Divide attention between flying the aircraft and navigating
    a. Focusing too much attention on either one of these can result in the other being neglected
        - Getting lost, or getting off altitude, improper fuel settings, etc.
ii. A loss of situational awareness is considerably more difficult to regain in a stressful, busy situation such as this
iii. Ways to Maintain Situational Awareness
    a. Verify all programming
    b. Check the flight routing
    c. Verify waypoints
    d. Make us of all onboard navigation equipment (for example, backup the GPS with a VOR)
    e. Match the use of the automated system with pilot proficiency
    f. Plan a realistic flight route to maintain situational awareness

C. Task Management
i. Attention needs to be divided between handling the aircraft, scanning for other traffic, communicating with ATC, and navigating to your destination
    a. No one responsibility should take your full attention full more than a short period
        - Continually move between tasks to ensure everything is being taken care of
    b. It is easy to get drawn into setting up navaids or adjusting autoflight systems
        - Always stop to give attention to flying the aircraft (altitude, airspeed, power settings, etc.) and scanning for other traffic
    c. Safety is your number one priority
        - Aviate, Navigate, Communicate

3. Limitations of the Navigation System in use

A. VOR

- i. Line of sight only
  - a. A weak or no signal at all is received if the aircraft is too low or too far from the station
  - b. Unusable Areas
    - Certain VORs have been shown to be unusable in certain areas; these will be published in NOTAMs (for example, radial 095 clockwise to 120, within 15 nm)
- ii. Limited useful distance based on type of VOR (terminal, low, high)

B. NDB/ADF
- i. Very susceptible to electrical disturbances, such as lightning
  - a. Creates excessive static, needle deviations, and signal fades
- ii. Potential for interference from distant stations
  - a. NDB is not affected by line-of-sight
- iii. Often found to be initially confusing to use (relative bearing vs magnetic heading)

C. GPS
- i. Database Currency
  - a. If expired, update the database. An expired database may be missing waypoints, have waypoints that have since been removed, or have incorrect information regarding waypoints
- ii. User Error
  - a. Verify the waypoints prior to flight, rather than in flight, to prevent navigation error
    - Ensure the route intended is entered in the GPS
- iii. Loss of Signal
  - a. Although rare, a loss of signal can leave the pilot without navigational information
    - This is more likely with a hand-held GPS
  - b. RAIM (Receiver Autonomous Integrity Monitoring)
    - Used to ensure the GPS has the proper number of satellites in view in order to provide a reliable signal and navigation
      - a A RAIM annunciation means that the system is not able to guarantee your position since it cannot see enough satellites
    - If this is not a feature of your GPS, be suspicious of a GPS position when any disagreement exists with the position derived from other radio navigation systems

D. Loss of Navigation Signal
- i. Do not rely on a single source of navigation
  - a. Always maintain situational awareness. For example, sole reliance on GPS to the extent that the pilot is unaware of his or her position can quickly turn into being lost in the case of a GPS failure
  - b. Always maintain a backup source of navigation while flying and maintain awareness of your location. In the case of a failure, revert to the secondary source
- ii. Troubleshoot the Issue, if possible
  - a. Rather than assuming the navigation signal is lost, attempt to fix the problem, and/or revert to another means of navigation

SKILLS

The applicant demonstrates the ability to:

1. Use an airborne electronic navigation system.
2. Determine the airplane's position using the navigation system.
3. Intercept and track a given course, radial, or bearing, as appropriate.
4. Recognize and describe the indication of station or waypoint passage, if appropriate.
5. Recognize signal loss or interference and take appropriate action, if applicable.

6. Use proper communication procedures when utilizing radar services.
7. Maintain the appropriate altitude, ±200 feet and heading ±15°.

VI.C. Diversion

References: Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM, Navigation Charts

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Selecting an Alternate Destination**
    A. On the Ground
        i. Once the course is plotted, survey the route of flight looking for available alternate airports along the route
            a. Look at the terrain (mountains, swamps, water, etc.) that would have impact if the alternate airport were necessary
            b. Look at the distance from the alternate(s) to the destination and the planned route of flight
            c. Look at the alternate airport itself
                - Ensure the airport can support your needs (fuel requirements, runway length, parking, etc.)
            d. Look at the surrounding airspace, ensure you have the training, and equipment to enter/transit the required airspace
        ii. Mentally prepare for any situation and the appropriate action to be taken
            a. What fuel level will necessitate going to the alternate?
            b. What weather conditions would require the alternate to be used?
            c. Have a plan prior to needing one
    B. In the Air
        i. Determine where to go
            a. Use the alternate selected on the ground during preflight planning
            b. If unable, find a nearby alternate using your current location, the map, GPS, ATC, or whatever other information you have on hand
                - Use all information available
        ii. Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance
            a. Use your thumb to estimate distance
                - Using the scale on your map, figure out approximately how far from the fingertip of your thumb (toward the knuckle) 10 nm is
                - In the case of a diversion use your thumb to quickly measure the number of 10 nm increments to the alternate airport
                - This will provide a rough distance estimate for quicker, less stressful time and fuel calculations
            b. Use a compass rose, airway or any other reference to determine the approximate new heading
        iii. Procedure
            a. Confirm your present position on the sectional chart
            b. Divert immediately toward the alternate using shortcuts/rule of thumb calculations (above)
                - Completing all measuring, plotting, computations first may aggravate the situation
            c. Once established on course, note the time
            d. Use the winds aloft nearest the diversion point to calculate a heading and ground speed
                - Once determined, calculate a new arrival time and fuel consumption
                - Give priority to flying while dividing attention between navigation and planning

e. When determining an altitude, consider cloud heights, winds, terrain, etc.

2. Situations that Require Deviations from Flight Plan or ATC Instruction

A. Flight Plan

i. There may very well be a time when it is necessary to deviate from the flight plan for various reasons. Things such as weather, TFRs, hazards, change in destination, airport closures, etc. can require a change in the flight plan

a. Computing course, time, speed, and distance information in flight requires the same computations used during preflight planning, however because of the limited space and attention available, use all possible shortcuts and rule of thumb computations

- Instead of plotting a new course, measure the course to your new destination using a straight edge and a compass rose around a VOR (simply maintain the desired course and move the straight edge over the compass rose to read the course)
- Once on course, note the time and use the winds aloft nearest your diversion point to get a groundspeed and wind corrected heading, then find the fuel burn based on the time en route
- Change altitude as necessary based on the new route (direction

B. ATC Instruction

i. FAR 91.3(b): In an in-flight emergency, requiring immediate action, the pilot in command may deviate from any rule to the extent required to meet that emergency

a. Each pilot who deviates from a rule shall, upon the request of the Administrator, send a written report of that deviation to the Administrator

ii. Aviate, Navigate, Communicate

a. Fly the plane, then when time and conditions permit advise ATC of your actions and intentions

- ATC not only can provide assistance, but needs to be able to move other traffic that may be a hazard

iii. Situations that can require a deviation from ATC Instructions can vary widely. Examples include, traffic hazards, terrain hazards, emergency situations in the aircraft (engine problems, fuel problems, etc.), weather hazards, etc.

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Collision Hazards, to Include Aircraft, Terrain, Obstacles, and Wires

A. Aircraft

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other’s right has the right-of-way.
- If they are different categories:

        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

   c. Approaching Head-on
      - Each pilot shall alter course to the right
   d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
   e. Landing
      - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
      - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        a Don’t take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Cruise Altitude
   a. Even thousands plus 500’ when flying a magnetic course between 180 and 359 degrees
   b. Odd thousands plus 500’ when flying a magnetic course between 0 and 179 degrees

v. Clearing Procedures
   a. Before Takeoff: Scan the runway and final approach for other traffic
   b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   c. During cruise use the scanning techniques below, and if necessary, use gentle banks to search for other traffic

vi. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

vii. High Traffic Areas

        a. Flying on or near airways (especially around navaids where multiple airways converge) can draw a lot of traffic, be vigilant in looking for other aircraft

B. Terrain
    i. Be aware of terrain en route, and any terrain that could cause a hazard during the climb or descent into the airfield
        a. Study sectionals and terminal area charts
        b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
        c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
    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
            - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
        b. A personal minimum may be to only fly over high terrain during daylight
    iii. Prior to flight you should have analyzed the terrain between your route, the destination and all potential alternates
        a. Be aware of any terrain that may necessitate a climb
            - Know the altitude required to clear the terrain (use a sectional) and be aware of the aircraft's expected performance
                a Follow the cruising altitude rules
                b If too heavy or too hot, the aircraft may not be able to reach the altitude required, making the alternate unusable
            - If it's not possible to overfly the terrain, know if flying around it is an option
                a Fuel is likely your biggest concern in this situation, but also be aware of weather, traffic, airspace, etc.

C. Obstacle and Wire Strike Avoidance
    i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
        a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb/descent
        b. Become familiar with any obstacles on the arrival and departure paths
        c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
        d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
        e. NOTAMs are issued on lighted structures experiencing light outages
    ii. Antenna Towers
        a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
            - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
    a. Ensure proper clearance between the aircraft and obstacle
        - If unsure of clearance, stop until you're sure it is safe to pass
v. If necessary, radio ground to inform them of your intentions or ask for assistance

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
  i. Attention must be divided between flying the aircraft to a set of standards and planning the diversion
    a. Do not lose control of the aircraft's heading and altitude while trying to figure out what course, altitude and speed is required for the diversion
    b. Automation is a great tool to assist during a diversion
    c. Without automation, trim the aircraft as well as possible and take frequent breaks from planning to attend to aircraft control
  ii. Distractions during a diversion can be dangerous
    a. Changing altitudes can result in potential midair collisions
    b. Changing headings not only lengthens the time to reach the alternate, but also can result in a loss of situational awareness if continued unnoticed
  iii. Fly first!
    a. Aviate, Navigate, Communicate
    b. The pilot, especially in the case of pilotage and dead reckoning, can easily be distracted from flying the aircraft by reading the chart, looking for waypoints, figuring out their location, etc.
        - Be sure to divide time between the aircraft and the other tasks
        - Use automation, if available to reduce the pilot's workload
            a This in no way alleviates the pilot's responsibility of monitoring the automation and ensure the aircraft is still flying as desired
  iv. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
  v. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the current phase of flight

B. Situational Awareness
  i. The most obvious risk associated with a loss of situational awareness is getting lost
    a. This has become more difficult with GPS navigation, but if the GPS fails, many pilots would lose a large majority, if not all of their situational awareness
    b. Getting lost can result in numerous problems of its own
        - Issues associated with fuel can quickly become a problem
        - Things such as unexpected weather, traffic or terrain can come into play
  ii. Always divide attention between navigation, and flying the aircraft
  iii. Use all resources available
    a. GPS, VORs, NDBs, ATC, other aircraft (emergency frequency), cell phone, etc.
  iv. Avoiding Becoming Lost
    a. Always know where you are - Plan ahead, Know the next landmark/Anticipate navigation indications
    b. If the radio navigation systems/visual observations do not confirm expectations, take corrective actions
    c. Use multiple landmarks to verify your position

- If possible don't depend on one landmark

v. If you do become lost:
   a. Don't Panic
   b. Use the Five C's
      - Climb – This will allow you to see more ground, increasing chances of spotting a landmark
        - a Improves radio reception, extends the transmitter range, and increases radar coverage
      - Communicate – use the frequencies on the chart, including RCO frequencies at VOR stations
        - a A controller can provide radar vectors
        - b Use 121.5 if the situation becomes threatening and squawk 7700
      - Confess – Tell any ATC facility the situation
      - Comply – Comply with any ATC suggestions
      - Conserve – Reduce power/airspeed for max endurance or range (whichever is appropriate)
   c. In addition,
      - Check the heading indicator with the magnetic compass
        - a If there is an error, note the direction of error before resetting the heading indicator
        - b This can help determine whether you are right or left of course
      - EX: if the compass indicates 10° > than the heading indicator, you may be to the right of course
   d. Use navigational radios (VOR/ADF) to attempt to plot your position in relation to two navaids
      - The GPS can also be used to determine location
   e. If near a town, the name of the town may be visible on a water tower

C. Task Management
   i. Attention needs to be divided between handling the aircraft, scanning for other traffic, communicating with ATC, and navigating to your destination
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
         - Focusing too much attention on any one task (i.e., reading the map) can result in the others being neglected
           - a Results in getting lost, off altitude, improper fuel settings, etc.
      b. It is easy to get drawn into a map or looking intently for a checkpoint
         - Always stop to give attention to flying the aircraft (altitude, airspeed, power settings, etc.) and scanning for other traffic
   ii. Safety is your number one priority
   iii. Aviate, Navigate, Communicate
   iv. Failure to manage all tasks associated with diverting can result in numerous issues
      a. Lack of planning: fuel, course, speed, altitude, etc. can all lead to emergencies or a loss of situational awareness/getting lost
      b. Lack of communication with ATC can result in a reduction of situational awareness
         - If using flight following, keep ATC in the loop so they can provide relevant information
   v. Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance as discussed above

3. Failure to make a Timely Decision to Divert

A. Have a plan before you need one
   i. Have set minimums/requirements that will trigger a diversion to an alternate field
      a. Have a set fuel amount that when reached will trigger the diversion
         - This should not be an issue, but if changes in winds, weather, airspeeds, mechanical issues or whatever else occur you may be forced to divert

b. Have set weather minimums that will trigger the divert
    - Of course, if the weather goes below VMC you'll have to divert, but if the weather is slowly getting worse en-route, have a limit at which you will abort the original plan and head to the alternate

c. Each flight is different and may have different requirements that will trigger a diversion
    - Consider the flight, the reason for flying, the weather, terrain, airspace, aircraft, airports, and anything else that may have an effect and have a plan for when you will divert/what conditions will lead to a diversion.

4. Failure to Select an Appropriate Airport

A. Selecting an inappropriate airport can result in a myriad of problems

i. For example, you may not be able to reach the alternate due to terrain, you may not have sufficient fuel, the runway may not be able to support your landing distance requirements, the weather may not support a diversion, the airport may be closed due to a TFR, one or more runways may be closed, or once on the ground you may not be able to service your aircraft

ii. Always research the airfield thoroughly to ensure you don't complicate an already complicated situation, or end up in an emergency situation

5. Failure to Utilize all Available Resources while Diverting

A. A huge facet of Crew Resource Management is effectively using all resources. All too often an issue is encountered and the pilot doesn't make use of all available resources that could help fix the situation

i. Even though you may not be flying a crew aircraft, the concept still applies

ii. On the aircraft, things such as navigational capabilities (GPS, VOR, ADF, etc.), radios, other passengers (even if they aren't pilots can help look for landmarks or other traffic), sectional charts, Chart supplements, whatever other publications you have on hand, your cell phone, etc. can be of assistance

iii. Outside the aircraft (remember you're not isolated in the aircraft), things such as ATC, FSS, and other aircraft can provide assistance. Use your cell phone to call someone who can help the situation, whether that's a tower, ATC, a flight instructor or anyone else.

iv. What else can you think of that could provide assistance? Be creative, think outside the box

SKILLS

The applicant demonstrates the ability to:

1. Select a suitable airport and route for diversion.
2. Make a reasonable estimate of heading, groundspeed, arrival time, and fuel consumption to the divert airport.
3. Maintain the appropriate altitude, ±200 feet and heading, ±15°.
4. Update/interpret weather in flight.
5. Explain and use flight deck displays of digital weather and aeronautical information, as applicable.

VI.D. Lost Procedures

References: Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM, Navigation Charts

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Methods to Determine Position**
   - A. NAVAIDs
     - i. If the aircraft has a navigational radio, such as a VOR or ADF, it can be possible to determine position by plotting an azimuth from two or more navigational facilities
       - a. By finding the radial from two different navaids that the aircraft is currently on, the pilot can find the aircraft's position where the two lines cross
     - ii. If GPS is installed, or the pilot has a portable GPS, it can be used to determine the position and location of the nearest airport (and of your aircraft)
   - B. Communication
     - i. Communicate with any available frequencies shown on the sectional chart
       - a. If contact is made, radar vectors may be offered
         - ATC can also assign you a squawk code to allow easier recognition and assistance
       - b. Other facilities may offer direction finding assistance
         - To use this procedure, the controller requests the pilot to hold the transmit button for a few seconds and then release it. The controller may ask the pilot to change direction a few times and repeat the transmit procedure. This gives the controller enough information to plot the aircraft position and then give vectors to a suitable landing site
     - ii. If the situation becomes threatening, transmit the situation on the emergency frequency 121.5 and set the transponder to 7700
       - a. Most facilities, airliners, and military aircraft monitor the emergency frequency
   - C. Geographic References
     - i. If a town or city cannot be seen, the first thing to do is climb, being mindful of traffic and weather conditions
       - a. An increase in altitude may allow the pilot to see other references
       - b. If flying near a town or city, it may be possible to read the name of the town on the water tower
       - c. An increase in altitude also increases radio and navigation reception range and also increases radar coverage
2. **Assistance Available if Lost**
   - A. In the Aircraft
     - i. Navigational capabilities (GPS, VOR, ADF, etc.), radios, other passengers (even if they aren't pilots) can help look for landmarks or other traffic or verify the gear is down, sectional charts, Chart supplements, or whatever other publications you have on hand, your cell phone, etc.
   - B. Outside the Aircraft
     - i. Outside the aircraft (remember you're not isolated in the aircraft), things such as ATC, FSS, and other aircraft can provide assistance. Use your cell phone to call someone who can help the situation, whether that's a tower, ATC, a flight instructor or anyone else
   - C. Use any radar services available (request flight following/transponder codes, direction finding assistance, etc.) and communications procedures available (ATC, 121.5, sectional frequencies, FSS, etc.)
   - D. Be creative, think outside the box

The following is no longer included in the ACS:

3. **The Value of Recording time at Waypoints**
   A. Recording the time at waypoints allows you to see how the actual weather compares to the weather that was used for planning and therefore the accuracy of your groundspeed and flight planning
      i. If you are ahead or behind the planned time you can adjust the time between legs based on the new groundspeed
   B. An incorrect time estimate can make finding your waypoints difficult which can result in uncertainty in regards to your location
      i. When the timing is off and you're uncertain of your location, it's easier to think you're somewhere you aren't and make a turn at the wrong time and/or point. Worst case this leads to getting lost, best case you realize you're off course and have to find your way back
   C. Recording time at waypoints goes a long way to ensuring you stay on course
4. **Responsibility and Authority of the PIC**
   A. FAR 91.3
      i. The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft
      ii. In an in-flight emergency requiring immediate action, the pilot in command may deviate from any rule of this part to the extent required to meet that emergency
      iii. Each pilot in command 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
   B. AIM
      i. The pilot in command of an aircraft is directly responsible for and is the final authority as to the operation of that aircraft. In an emergency requiring immediate action, the pilot in command may deviate from any rule in 14 CFR Part 91, Subpart A, General, and Subpart B, Flight Rules, to the extent required to meet that emergency.
      ii. If the emergency authority of 14 CFR Section 91.3(b) is used to deviate from the provisions of an ATC clearance, the pilot in command must notify ATC as soon as possible and obtain an amended clearance
         a. This is for everyone's safety. ATC needs to know what you are doing
5. **Deviation from ATC Instructions**
   A. Same as above. A deviation is allowed in the case of an emergency
   B. If you do deviate, be sure to inform ATC as soon as time permits
6. **Declaring an Emergency**
   A. An emergency can be either a distress or urgency condition as defined in the Pilot/Controller Glossary
      i. Distress: A condition of being threatened by serious and/or imminent danger and of requiring immediate assistance
      ii. Urgency: A condition of being concerned about safety and of requiring timely but not immediate assistance; a potential distress condition
   B. Pilots do not hesitate to declare an emergency when they are faced with distress conditions such as fire, mechanical failure, or structural damage, however, some are reluctant to report an urgency condition when they encounter situations which may not be immediately perilous, but are potentially catastrophic
      i. An aircraft is in at least an urgency condition the moment the pilot becomes doubtful about position, fuel endurance, weather, or any other condition that could adversely affect flight safety. This is the time to ask for help, not after the situation has developed into a distress condition
   C. Pilots who become apprehensive for their safety for any reason should request assistance immediately

i. Ready and willing help is available in the form of radio, radar, direction finding stations and other aircraft
ii. Delay has caused accidents and cost lives. Safety is not a luxury - Take action

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Collision Hazards, to Include Aircraft, Terrain, Obstacles, and Wires

- A. Aircraft
  - i. Do not become overburdened with being lost and forgot to be alert for collision hazards
    - a. As always, fly first. Manage the tasks as appropriate and do not become distracted
  - ii. Operation Lights On
    - a. A voluntary FAA safety program to enhance the see and avoid concept
    - b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
  - iii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
      - If they are different categories:
        - a A balloon has the right of way over any other category
        - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    - c. Approaching Head-on
      - Each pilot shall alter course to the right
    - d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    - e. Landing
      - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
      - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        - a Don't take advantage of this rule to cut in front of another aircraft
  - iv. Minimum Safe Altitudes (FAR 91.119)
    - a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:

- 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

v. Cruise Altitude
  a. Even thousands plus 500’ when flying a magnetic course between 180 and 359 degrees
  b. Odd thousands plus 500’ when flying a magnetic course between 0 and 179 degrees

vi. Clearing Procedures
  a. Before Takeoff: Scan the runway and final approach for other traffic
  b. During the climb execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
  c. During cruise use the scanning techniques below, and if necessary, use gentle banks to search for other traffic

vii. Scanning
  a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

viii. High Traffic Areas
  a. Flying on or near airways (especially around navaids where multiple airways converge) can draw a lot of traffic, be vigilant in looking for other aircraft

B. Terrain

i. Be aware of terrain en route, and any terrain that could cause a hazard during the climb or descent into the airfield
  a. Study sectionals and terminal area charts
  b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
  c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
    - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
  b. A personal minimum may be to only fly over high terrain during daylight

iii. Prior to flight you should have analyzed the terrain between your route, the destination and all potential alternates
  a. Be aware of any terrain that may necessitate a climb
    - Know the altitude required to clear the terrain (use a sectional) and be aware of the aircraft’s expected performance
      a Follow the cruising altitude rules
      b If too heavy or too hot, the aircraft may not be able to reach the altitude required, making the alternate unusable
    - If it’s not possible to overfly the terrain, know if flying around it is an option

        a Fuel is likely your biggest concern in this situation, but also be aware of weather, traffic, airspace, etc.

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and climb/descent
      b. Become familiar with any obstacles on the arrival and departure paths
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing
   iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
      a. Ensure proper clearance between the aircraft and obstacle
         - If unsure of clearance, stop until you're sure it is safe to pass
   v. If necessary, radio ground to inform them of your intentions or ask for assistance

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. Attention must be divided between flying the aircraft and handling the lost situation
      a. Do not lose control of the aircraft's heading and altitude while trying to figure out what course, altitude and speed is required
      b. Automation is a great tool to assist the pilot in a lost situation
      c. Without automation, trim the aircraft as well as possible and take frequent breaks from other responsibilities to attend to aircraft control
   ii. Distractions during can be dangerous
      a. Changing altitudes can result in potential midair collisions
      b. Changing headings not only lengthens the time to reach the alternate, but also can result in a loss of situational awareness if continued unnoticed
   iii. Fly first!
      a. Aviate, Navigate, Communicate
      b. The pilot, especially in the case of being lost, can easily be distracted from flying the aircraft by reading the chart, looking for waypoints, figuring out their location, etc.
         - Be sure to divide time between the aircraft and the other tasks
         - Use automation, if available to reduce the pilot's workload
            a This in no way alleviates the pilot's responsibility of monitoring the automation and ensure the aircraft is still flying as desired

iv. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
v. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the current phase of flight

B. Situational Awareness
  i. The most obvious risk associated with a loss of situational awareness is getting lost
    a. This has become more difficult with GPS navigation, but if the GPS fails, many pilots would lose a large portion, if not all, of their situational awareness
    b. Getting lost can result in numerous problems of its own
      - Issues associated with fuel can quickly become a problem
      - Things such as unexpected weather, traffic or terrain can come into play
  ii. Always divide attention between navigation, and flying the aircraft
  iii. Use all resources available
    a. GPS, VORs, NDBs, ATC, other aircraft (emergency frequency), cell phone, etc.
  iv. Do what you can to avoiding Becoming Lost
    a. Always know where you are - Plan ahead, Know the next landmark/Anticipate navigation indications
    b. If the radio navigation systems/visual observations do not confirm expectations, take corrective actions
    c. Use multiple landmarks to verify your position
      - If possible don't depend on one landmark
  v. If you do become lost:
    a. Don't Panic
    b. Use the Five C's
      - Climb – This will allow you to see more ground, increasing chances of spotting a landmark
        a Improves radio reception, extends the transmitter range, and increases radar coverage
      - Communicate – use the frequencies on the chart, including RCO frequencies at VOR stations
        a A controller can provide radar vectors
        b Use 121.5 if the situation becomes threatening and squawk 7700
      - Confess – Tell any ATC facility the situation
      - Comply – Comply with any ATC suggestions
      - Conserve – Reduce power/airspeed for max endurance or range (whichever is appropriate)
    c. In addition,
      - Check the heading indicator with the magnetic compass
        a If there is an error, note the direction of error before resetting the heading indicator
        b This can help determine whether you are right or left of course
      - EX: if the compass indicates 10° > than the heading indicator, you may be to the right of course
    d. Use navigational radios (VOR/ADF) to attempt to plot your position in relation to two navaids
      - The GPS can also be used to determine location
    e. If near a town, the name of the town may be visible on a water tower

C. Task Management
  i. Attention needs to be divided between handling the aircraft, scanning for other traffic, communicating with ATC, and navigating to your destination
    a. No one responsibility should take your full attention full more than a short period

- Continually move between tasks to ensure everything is being taken care of
- Focusing too much attention on any one task (i.e., reading the map) can result in the others being neglected
    - a Results in getting lost, off altitude, improper fuel settings, etc.

b. It is easy to get drawn into a map or looking intently for a checkpoint
- Always stop to give attention to flying the aircraft (altitude, airspeed, power settings, etc.) and scanning for other traffic

ii. Safety is your number one priority
iii. Aviate, Navigate, Communicate
iv. Failure to manage all tasks associated with diverting can result in numerous issues
a. Lack of planning: fuel, course, speed, altitude, etc. can all lead to emergencies or a loss of situational awareness/getting lost
b. Lack of communication with ATC can result in a reduction of situational awareness
- If using flight following, keep ATC in the loop so they can provide relevant information

v. Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance as discussed above

3. Failure to Record Times over Waypoints

A. Recording times over waypoints provides a double check for your flight planning
i. If the times are early or late, the groundspeed is different from expected and adjustments can be made
ii. Incorrect timing makes it very difficult to find your waypoints since you're not over them when you expect to be
a. It becomes considerably easier to miss a waypoint or turn at the wrong point and can lead to a lost situation

4. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. Understand that hiding or delaying the problem only makes the situation worse
i. Be proactive in handling any situation and in the case that it becomes an emergency, declare an emergency to ATC and get the aircraft on the ground

B. Use all assistance available, and declare an emergency when necessary
C. As mentioned before, pilots who become apprehensive for their safety for any reason should request assistance immediately
i. Ready and willing help is available in the form of radio, radar, direction finding stations and other aircraft
a. Delay has caused accidents and cost lives. Safety is not a luxury – Take action

SKILLS

The applicant demonstrates the ability to:

1. Use an appropriate method to determine position.
2. Maintain an appropriate heading and climb as necessary.
3. Identify prominent landmarks.
4. Use navigation systems/facilities and/or contact an ATC facility for assistance.

SLOW FLIGHT & STALLS

VII.A. Maneuvering During Slow Flight

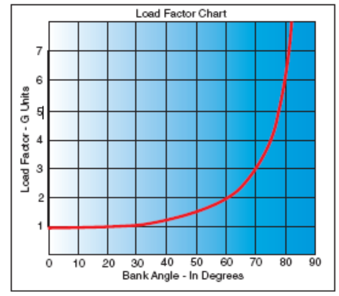
References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

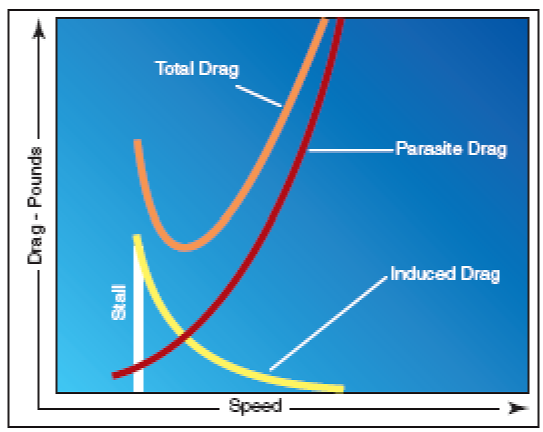
1. **Aerodynamics Associated with Slow Flight in Various Aircraft Configurations, to include the Relationship Between:**
   A. Angle of Attack (AOA)
      i. Defined: The acute angle between the chord line of the airfoil and the direction of the relative wind
         a. As the airspeed slows, the angle between the chord line and the relative wind increases (assuming everything else remains the same)
            - For example, imagine straight and level flight at 100 knots. As the aircraft slows to 60 knots, in order to maintain straight and level flight, the nose must be raised (the lift lost due to the decreasing airspeed is replaced by increasing the angle of attack). Therefore, the relative wind remains the same (the aircraft is still straight and level), but the angle of attack is considerably higher than at 100 knots.
      ii. AOA and Airspeed
         a. As mentioned above, decreasing airspeed necessitates an increasing AOA to maintain lift and vice versa (increasing airspeed, requires a decreasing angle of attack to maintain the same amount of lift)
      iii. AOA and Load Factors
         a. As the load factor ("weight") increases, the AOA must be increased to compensate for the additional weight and the opposite applies (less load factor = less AOA)
      iv. AOA and Configuration
         a. When the flaps are lowered, the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
            - For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
      v. AOA and Weight
         a. Increased weight results in an increased AOA to maintain altitude. The heavier the plane the more lift required and vice versa
      vi. AOA and Attitude
         a. Changing the AOA usually is a direct change in the aircraft attitude, specifically the pitch of the aircraft
   B. Airspeed
      i. An increase or decrease in airspeed increases or decreases lift and thus can have an effect on AOA and the attitude of the aircraft
         a. AOA would have to increase with a loss of airspeed and vice versa
         b. The aircraft attitude would change simply because the pitch is being adjusted to increase the AOA to compensate for the loss of airspeed
      ii. In relation to slow flight, the slower the airspeed, the higher the AOA required to compensate for the decreased lift
   C. Load Factor

i. Load factor is the ratio of the total load acting on the airplane to the gross weight of the airplane
    a. Expressed in terms of G's



ii. Turns
    a. Increased load factors are a characteristic of all banked turns
    b. Load factor increases at a high rate after 45°-50° of bank
iii. An increased load factor effectively increases the weight of the aircraft during the time that the load factor is imposed
    a. For example, in cruise flight an aircraft may be at 1 G and weigh 2,000 lbs. In a 60-degree banked turn holding altitude the aircraft is at 2 G's and effectively has increased its weight to 4,000 lbs. while at 2 G's
    b. The increased load factor requires a higher AOA or airspeed or both to compensate for the additional load during the maneuver
iv. An increase or decrease in the load factor effectively increases or decreases the weight of the aircraft and thus can affect the AOA, airspeed, weight, and attitude of the aircraft
    a. An increased load factor effectively makes the aircraft seem heavier to the flight controls and therefore, to maintain altitude the AOA would have to be increased to generate the additional lift required
    b. An increased load factor could also be compensated for by increasing the airspeed
        - This would generate additional lift to compensate for the "increased weight" and thus allow the AOA to stay the same

D. Power Setting
i. When performing slow flight, it is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed
    a. As airspeed decreases from cruise to L/D_{MAX}, total drag and thrust required decrease to maintain a constant altitude
    b. As airspeed decreases below L/D_{MAX}, additional power (thrust) is required to maintain a constant altitude
        - Total drag is now increasing because induced drag increases faster (due to higher the angle of attack) than parasite drag decreases
        - This is known as the 'backside of the power curve' or the 'region of reverse command'
            a The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude



ii. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components
    a. In slow flight, thrust no longer acts parallel to and opposite to the flight path and drag.
        - In slow flight, thrust has two components:
            a One acting perpendicular to the flight path in the direction of lift
            b One acting along the flight path
    b. Because the actual thrust is inclined, its magnitude must be greater than drag if its component acting along the flight path is equal to drag

        - The forces acting upward (wing lift and the component of thrust) equal the forces acting downward (weight and tail down force)
    c. Wing loading is actually less during slow flight because the vertical component of thrust helps support the airplane
  iii. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over them
    a. As airspeed decreases, control effectiveness decreases disproportionately
        - There is a loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed, but there is a considerably greater loss as the airspeed is reduced to 10 knots above the stall speed
    b. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high power setting condition
    c. Large control movements may be required
    d. This does not mean rough or jerky movements

E. Aircraft Weight
  i. An increase in weight is similar to an increase in load factor, except that the increased weight exists throughout the entire flight, rather than during the specific maneuver that will change the aircraft's load factor (G's)
    a. Increasing weight requires an increased AOA or airspeed to compensate for the additional lift required

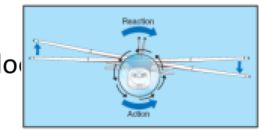
F. Center of Gravity
  i. An airplane with forward loading
    a. The aircraft acts heavier, and consequently slower than the same airplane with a further aft CG
        - Nose up trim is required which requires the tail surfaces to produce a greater download which adds to the wing loading and the total lift required to maintain altitude
    b. Requires a higher angle of attack, resulting in more drag and a higher stall speed
    c. The aircraft is more controllable though
        - This is due to the longer arm from the elevator to the CG
  ii. With aft loading (aircraft acts lighter), the airplane requires less download allowing for a faster cruise speed
    a. Faster cruise because of reduced drag
        - Reduced drag is a result of a smaller angle of attack and less downward deflection of the stabilizer
    b. The tail surface is producing less down load, relieving the wing of loading and lift required to maintain altitude
        - Results in a lower stall speed
    c. Recovery from a stall becomes progressively more difficult as the CG moves aft
        - Moving the CG aft shortens the arm from the elevator, reducing the amount of force it can apply

G. Aircraft Attitude
  i. A change in attitude is simply a change in the aircraft's position in space. Everything else remaining the same, all of the factors will have some effect on the aircraft's attitude and most likely will result in an increase or decrease in pitch

H. Yaw Effects
  i. Torque (the left turning tendency of the aircraft) is made up of 4 elements which produce a twisting axis around at least 1 of the aircraft's 3 axes

a. Torque Reaction, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Prop, and P-Factor

ii. Torque Reaction



- Although torque reaction is more of a rolling tendency than a yaw effect, it do to the left turning tendencies of the aircraft

b. Newton's 3rd Law – For every action there is an equal and opposite reaction

- The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction

c. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency

d. On the ground, during takeoff, the left side is being forced down resulting in more ground friction

- This causes a turning moment to the left that is corrected with rudder
  - a Strength is dependent on engine size/hp, propeller size/rpm, plane size and ground surface
    1. The higher the power setting, the greater the left turning tendency

e. Torque is corrected by offsetting the engine, and using aileron trim tabs, and aileron/rudder use

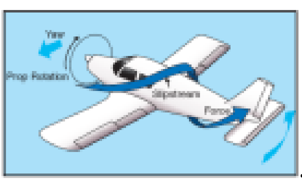
- Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset in order to counteract a portion of the rolling motion caused by torque
- Trim tabs can be adjusted to counter the turning tendency in level flight
- Torque that is not countered by the engine and trim tab position must be corrected with coordinate rudder and aileron inputs

iii. Corkscrew/Slipstream Effect

a. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft

- The 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 very compact



- This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
- The corkscrew flow also creates a rolling moment around the longitudinal axis
  - a The rolling moment is to the right and may counteract torque to an extent

. As the forward speed increases, the spiral elongates and becomes less effective

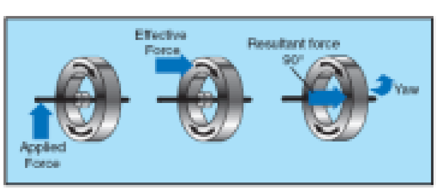
d. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in climbs (high prop speed and low forward speed)

e. In relation to slow flight, the high propeller speed and low forward speed results in a relatively pronounced slipstream effect which should be countered with right rudder, and aileron as necessary

iv. Gyroscopic Action

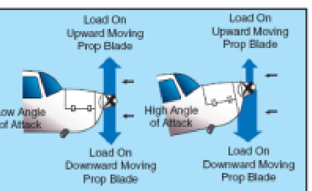
a. Gyroscopes are based on two fundamental principles:

- 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
    2. Ex: This most often occurs with tail wheel aircraft when the tail is being 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



        i. This force is felt 90° in the direction of rotation (clockwise as viewed from the cockpit)
    b. The forward force will take effect on the Right side of the propeller, yawing the aircraft Left
  b. In relation to slow flight, lifting the nose would result in a left yawing motion on the aircraft
    - Any yawing around the vertical axis results in a pitching moment
    - Any pitching around the lateral axis results in a yawing moment
    - Correction is made with necessary elevator and rudder pressures

v. Asymmetric Loading (P Factor)
  a. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade
    - This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)
  b. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc



    - At positive AOA, the right blade is passing through an area of resultant velocity greater than the left
    - Since the prop is an airfoil, increased velocity means increased lift
      a Therefore, the down blade has more lift and tends to yaw the plane to the left
  c. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)
    - If there were no air movement at all, except that generated by the prop, identical sections of the blade would have the same airspeed
    - 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
      a The blade proceeding is creating more lift or thrust, moving the center of lift toward it
    - Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
      a The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow
  d. Summary: The descending blade of the propeller 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 the aircraft will have a tendency to yaw to the left
  e. 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

I. Configuration
  i. In the case of configuration changes, we'll look simply at flaps and the gear
    a. Flaps
      - When the flaps are lowered the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
        a For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
      - Flaps also result in additional drag due to the increased lift and additional surface area protruding into the wind
      - Adding flaps can change the AOA, airspeed, and attitude of the aircraft
        a As mentioned above, the AOA changes since flaps are designed to influence the AOA
        b The airspeed will decrease due to the additional drag, and therefore power will have to be increased to maintain the same speed
        c Attitude will change due to the changing configuration, and AOA
    b. Gear

- In the case you have retractable gear, lowering the gear will result in additional drag and in some cases, it may affect the pitch of the aircraft and therefore make a small change to the AOA
- As gear is lowered, additional power is required to maintain airspeed and in the case that the gear does have an effect on the AOA, the pitch/attitude will have to be adjusted to compensate

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Inadvertent Slow Flight and Flight with a Stall Warning, which could Lead to a Loss of Control

A. Understand the slow flight maneuver in order to recognize and develop a feeling for, and control of the aircraft at airspeeds close to a stall

i. Be familiar with the pitch and power settings to maintain the slow flight airspeed desired

ii. Make small controlled corrections, use pitch for airspeed and power for altitude

a. Keep your scan moving. Primarily outside, while glancing inside to confirm the desired performance/instrument indications

iii. Slow Flight and the Senses

a. Visually

- 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
    1. Possibly a couple of clouds
- Hearing
  - a Initially, with the reduction of power, sound will decrease
  - b As you approach the stall, the stall warning horn will sound
  - c When power is reintroduced, the sound of the engine increases
    1. The sound of the plane moving through the air stays softer due to the slower airspeed
- Feel
  - a As the aircraft's speed continues to decrease, the controls will become progressively less responsive
    1. Larger control movements will be necessary to control the airplane as the air flow over the control surfaces has been reduced
  - b Right rudder will be necessary as the plane begins to yaw to the left
    1. This is due to the left turning tendencies upon reintroduction of power
    2. Due to reduced control effectiveness, more right rudder than normal is required
  - c Just prior to stalling the aircraft will begin to buffet

B. Recovery to Normal Flight

i. Just like a stall recovery

a. Full Power

b. Nose Down (forward pressure)

c. Clean up the airplane

- Flaps
- Gear (If necessary)

ii. Increase the power and lower the nose to begin building airspeed

a. Don't dive, apply forward pressure to maintain altitude as the aircraft accelerates

    iii. If configured, remove the first increment of flaps
        a. Anticipate the change in lift to maintain altitude
        b. The aircraft will have a tendency to sink, increase back pressure slightly to counter this
    iv. As airspeed increases and the aircraft exceeds V_Y remove the second increment of flaps
        a. Again, anticipate the change in lift to maintain altitude
    v. As airspeed increases, right rudder pressure will need to be reduced to maintain coordination
    vi. Reestablish a pitch and power setting appropriate for the phase of flight
C. Spin Recovery
    i. Recovery (PARE)
        a. Power - Idle
        b. Ailerons - Neutral
        c. Rudder - Full rudder opposite the spin direction
        d. Elevator - Brisk, positive forward pressure (nose down)
        e. Once the spin has stopped, neutralize the rudders and gently raise the nose, being careful not to stall the aircraft again
        f. This is a generic spin recovery, different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

2. Range and Limitations of Stall Warning Indicators

A. Stall Warning Horn
    i. The stall warning horn usually comes on prior to the stall onset to provide warning and time for recovery. Different stall warning horns have limited ranges and limitations associated with their operation. Reference the POH for more specifics on the stall warning horn installed on your aircraft.

3. Failure to Maintain Coordinated Flight

A. Slow flight, by definition, means the aircraft will be operated very close to its stall speed. Any increase in back pressure could potentially result in a stall. This can be hazardous, especially if the aircraft is not coordinated
    i. A stall & yaw are the ingredients necessary for a spin (basically, an uncoordinated stall)
    ii. Generally, the phases of flight in which the aircraft is in slow flight are close to the ground (takeoff and landing). A spin at these low altitudes may not be recoverable
B. Spins
    i. Prevention
        - Maintain coordination
        - Do not use abrupt, excessive pressure inputs (especially back elevator pressure)
        - Recover at the first sign of a stall
    b. Spin 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 gently raise the nose, being careful not to stall the aircraft again
        - This is a generic spin recovery, different aircraft respond differently to spins and spin recoveries, follow the recommended recovery procedures in the flight manual

4. Effect of Environmental Elements on Aircraft Performance

A. Turbulence
    i. When flying more slowly than minimum drag speed (LD/MAX) the aircraft will exhibit a characteristic know as speed instability

a. If the aircraft is disturbed by even the slightest turbulence, the airspeed will decrease. As airspeed decreases, the total drag also increases resulting in further loss in airspeed. The total drag continues to rise and speed continues to fall
   - Unless more power is applied and/or the nose is lowered, the speed will continue to decay right down to the stall

ii. The pilot must understand that, at speed less than minimum drag speed, the airspeed is unstable and will continue to decay if allowed to do so

B. Microbursts

i. A strong downdraft which normally occurs over horizontal distances of 1 NM or less and vertical distances of less than 1,000'. In spite of its small horizontal scale, an intense microburst could induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm.

ii. In a situation such as slow flight, when the aircraft is in a high angle of attack, high power, slow speed, there is minimal ability for the aircraft to climb, especially in the case of a microburst
   a. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common. In the case of a microburst, recover from slow flight and establish the best climb configuration and climb airspeed for your aircraft

iii. The FAA has developed a Pilot Windshear Guide Advisory Circular (AC 00-54)
   a. Included is information on how to recognize the risk of a microburst encounter, how to avoid an encounter and the best flight strategy for successful escape should an encounter occur

C. Density Altitude

i. Pressure Altitude
   a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
      - $1{,}000(29.92 - \mathrm{Alt}) + \mathrm{Elev}$
   b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
      - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
         a Therefore, aircraft takeoff and climb performance will improve with higher air pressure (shorter takeoff distance, and increased climb performance)
      - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather

ii. Density Altitude/Temperature
   a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
      - $120(℃ - 15℃) + \mathrm{PA}$ (this is an approximation)
   b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
      - Lower temperatures (the air is more compressed) result in better performance
      - Higher temperatures (the air is less compressed) result in poorer performance
      - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
         a Lower temperatures result in better performance (shorter takeoff run and increased climb performance)
         b Overall, high pressure, cold days result in the best takeoff and climb performance

iii. Humidity
   a. Although not directly accounted for on the performance charts, humidity decreases performance

iv. In relation to slow flight, the aircraft will perform better in lower pressure and density altitudes as well as with lower amounts of humidity and will perform worse in the opposite conditions
    a. Therefore, the aircraft will have a more difficult time maintaining airspeed and altitude in poorer atmospheric conditions

5. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Hazards and Slow Flight
  i. Slow flight can be a mentally taxing maneuver and is often performed in the busiest phases of flight (takeoff and landing). The combination of these two factors can result in the pilot becoming overly task saturated and increasing the risk of a collision
    a. Always divide attention between the aircraft and the environment
    b. Be aware of terrain and obstacles that may be in the aircraft's path

B. Collision Avoidance
  i. Operation Lights On
    a. A voluntary FAA safety program to enhance the see and avoid concept
    b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
  ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
      - If they are different categories:
        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    c. Approaching Head-on
      - Each pilot shall alter course to the right
    d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    e. Landing
      - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
      - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        a Don't take advantage of this rule to cut in front of another aircraft
  iii. Minimum Safe Altitudes (FAR 91.119)
    a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:

- 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Clearing Procedures
  a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
  b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
    - This is also more applicable to cruise, but can be used while the pattern, if necessary
  c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
  a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

C. Terrain
  i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  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
      - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

D. Obstacle and Wire Strike Avoidance
  i. Many structures exist that could significantly affect the safety of flight when operating below 500’ AGL and particularly below 200’ AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200’ AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages
  ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see

        - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing
    iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
        a. Ensure proper clearance between the aircraft and obstacle
            - If unsure of clearance, stop until you’re sure it is safe to pass
    v. If necessary, radio ground to inform them of your intentions or ask for assistance

6. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
    i. During slow flight, whether being practiced as a maneuver or when being used on takeoff or landing, the pilot’s attention should be focused on the tasks at hand (flying, looking for traffic, communication with ATC, etc.)
    ii. Fly first!
        a. Aviate, Navigate, Communicate
    iii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
    iv. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
        a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating at the speeds associated with slow flight. A loss of situational awareness can lead to unsafe situations, mishaps, as well as incursions on the ground or in the air
    i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    ii. Maintain situational awareness
        a. If it is lost, admit it. If there’s another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
    i. Attention needs to be divided between the various required tasks
        a. No one responsibility should take your full attention full more than a short period
            - Continually move between tasks to ensure everything is being taken care of
        b. Safety is your number one priority
            - Aviate, Navigate, Communicate
    ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        a. Checklists are extremely helpful in properly managing tasks
    iii. Recognize when you are getting behind the aircraft, 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
            a Don’t give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL) or 3,000 feet AGL (AMEL).
3. Establish and maintain an airspeed at which any further increase in angle of attack, increase in load factor, or reduction in power, would result in a stall warning (e.g., aircraft buffet, stall horn, etc.).
4. Accomplish coordinated straight-and-level flight, turns, climbs, and descents with landing gear and flap configurations specified by the evaluator without a stall warning (e.g., aircraft buffet, stall horn, etc.).
5. Maintain the specified altitude, ±100 feet; specified heading, ±10°; airspeed +10/-0 knots; and specified angle of bank, ±10°.

VII.B. Power-Off Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Stall and Spin Awareness Training (AC 61-67), POH/AFM

KNOWLEDGE

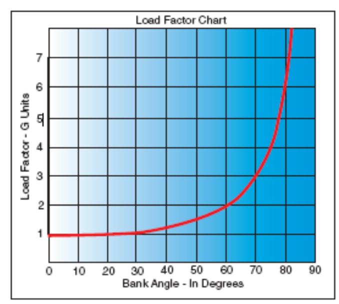
The applicant demonstrates understanding of:

1. **Aerodynamics Associated with Slow Flight in Various Aircraft Configurations, to include the Relationship Between:**
   A. Stall Aerodynamics
      i. A stall occurs when the smooth airflow over the wing is disrupted and lift decreases rapidly
         a. This is caused when the wing exceeds its critical angle of attack (AOA)
         b. This can occur at any airspeed, in any attitude, with any power setting
      ii. More Specifically…
         a. When the AOA is increased to approximately 15°-20° (usually 18°) the air can't follow the upper curvature of the wing
            - This is the critical AOA: the angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight
         b. As the critical AOA is approached, the air begins separating from the rear of the upper wing surface
            - As the AOA is further increased, the airstream is forced to flow straight back
               a This causes a swirling/burbling of air attempting to flow over the upper surface
            - When the critical AOA is reached, the turbulent airflow spreads over the entire upper wing
               a This results in a sudden increase in pressure on the upper surface and a decrease in lift
                  1. Due to the loss of lift and the increase in form drag (large area of the wing/fuselage is exposed to the turbulent airstream) the remaining lift can't support the plane and the wing stalls
   B. Angle of Attack (AOA)
      i. Defined: The acute angle between the chord line of the airfoil and the direction of the relative wind
         a. As the airspeed slows, the angle between the chord line and the relative wind increases (assuming everything else remains the same)
            - For example, imagine straight and level flight at 100 knots. As the aircraft slows to 60 knots, in order to maintain straight and level flight, the nose must be raised (the lift lost due to the decreasing airspeed is replaced by increasing the angle of attack). Therefore, the relative wind remains the same (the aircraft is still straight and level), but the angle of attack is considerably higher than at 100 knots.
      ii. AOA and Airspeed
         a. As mentioned above, decreasing airspeed necessitates an increasing AOA to maintain lift and vice versa (increasing airspeed, requires a decreasing angle of attack to maintain the same amount of lift)
         b. When the aircraft slows enough and reaches the critical angle of attack the aircraft will stall
      iii. AOA and Load Factors
         a. As the load factor ("weight") increases, the AOA must be increased to compensate for the additional weight and the opposite applies (less load factor = less AOA)
         b. Increased load factor results in an increased AOA which can lead to exceeding the critical angle of attack and a stall

- iv. AOA and Configuration
    - a. When the flaps are lowered, the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
        - For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
        - The aircraft now has a lower AOA than with the flaps retracted, the lower AOA means there is a greater distance between the aircraft's AOA and the critical AOA and therefore the aircraft will stall at a slower airspeed
- v. AOA and Weight
    - a. Increased weight results in an increased AOA to maintain altitude. The heavier the plane the more lift required and vice versa
    - b. The heavier the aircraft, the closer the AOA is to the critical angle of attack and easier it is to stall
- vi. AOA and Attitude
    - a. Changing the AOA usually is a direct change in the aircraft attitude, specifically the pitch of the aircraft

C. Airspeed
- i. An increase or decrease in airspeed increases or decreases lift and thus can have an effect on AOA and the attitude of the aircraft
    - a. AOA would have to increase with a loss of airspeed and vice versa
    - b. The aircraft attitude would change simply because the pitch is being adjusted to increase the AOA to compensate for the loss of airspeed
- ii. In relation to power-off stalls, the slower the airspeed, the higher the AOA required to compensate for the decreased lift and therefore the closer to the critical AOA and potentially a stall

D. Load Factor

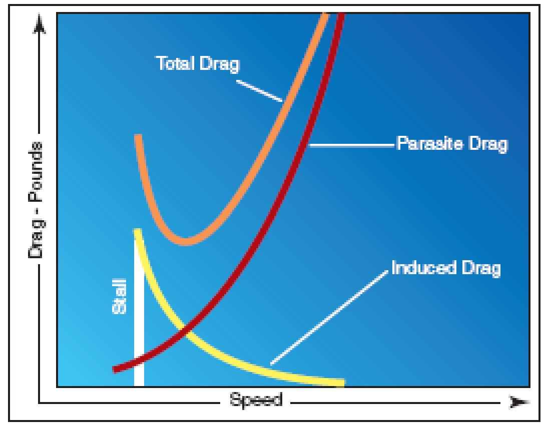


- i. Load factor is the ratio of the total load acting on the airplane to the gross weight of the airplane
    - a. Expressed in terms of G's
- ii. Turns
    - a. Increased load factors are a characteristic of all banked turns
    - b. Load factor increases at a high rate after 45°-50° of bank
- iii. An increased load factor effectively increases the weight of the aircraft during the time that the load factor is imposed
    - a. For example, in cruise flight an aircraft may be at 1 G and weigh 2,000 lbs. In a 60-degree banked turn holding altitude the aircraft is at 2 G's and effectively has increased its weight to 4,000 lbs. while at 2 G's
    - b. The increased load factor requires a higher AOA or airspeed or both to compensate for the additional load during the maneuver
- iv. An increase or decrease in the load factor effectively increases or decreases the weight of the aircraft and thus can affect the AOA, airspeed, weight, and attitude of the aircraft
    - a. An increased load factor effectively makes the aircraft seem heavier to the flight controls and therefore, to maintain altitude the AOA would have to be increased to generate the additional lift required
    - b. An increased load factor could also be compensated for by increasing the airspeed
        - This would generate additional lift to compensate for the "increased weight" and thus allow the AOA to stay the same
- v. In relation to power-off stalls, the higher the load factor, the higher the stall speed due to the higher AOA required

E. Power Setting

i. It is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed

a. As airspeed decreases from cruise to L/D_{MAX}, total drag and thrust required decrease to maintain a constant altitude



b. As airspeed decreases below L/D_{MAX}, additional power (thrust) is required to maintain a constant altitude
- Total drag is now increasing because induced drag increases faster (due to higher the angle of attack) than parasite drag decreases
- This is known as the 'backside of the power curve' or the 'region of reverse command'
  a The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude

ii. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components

a. In slow flight (which can often lead to a power-off stall), thrust no longer acts parallel to and opposite to the flight path and drag.
- In slow flight, thrust has two components:
  a One acting perpendicular to the flight path in the direction of lift
  b One acting along the flight path

b. Because the actual thrust is inclined, its magnitude must be greater than drag if its component acting along the flight path is equal to drag
- The forces acting upward (wing lift and the component of thrust) equal the forces acting downward (weight and tail down force)

c. Wing loading is actually less during slow flight because the vertical component of thrust helps support the airplane

iii. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over them

a. As airspeed decreases, control effectiveness decreases disproportionately
- There is a loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed, but there is a considerably greater loss as the airspeed is reduced to 10 knots above the stall speed

b. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high power setting condition

c. Large control movements may be required

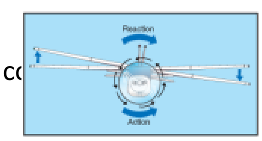
d. This does not mean rough or jerky movements

iv. In relation to a power-off stall, appropriate pitch and power settings should be used to maintain a stable approach speed and path since deviating from a stable approach can result in a stall

F. Aircraft Weight

i. An increase in weight is similar to an increase in load factor, except that the increased weight exists throughout the entire flight, rather than during the specific maneuver that will change the aircraft's load factor (G's)

        a. Increasing weight requires an increased AOA or airspeed to compensate for the additional lift required
    ii. Increased weight can lead to a power-off stall at higher airspeeds due to the higher AOA required
G. Center of Gravity
    i. An airplane with forward loading
        a. The aircraft acts heavier, and consequently slower than the same airplane with a further aft CG
            - Nose up trim is required which requires the tail surfaces to produce a greater download which adds to the wing loading and the total lift required to maintain altitude
        b. Requires a higher angle of attack, resulting in more drag and a higher stall speed
        c. The aircraft is more controllable though
            - This is due to the longer arm from the elevator to the CG
    ii. With aft loading (aircraft acts lighter), the airplane requires less download allowing for a faster cruise speed
        a. Faster cruise because of reduced drag
            - Reduced drag is a result of a smaller angle of attack and less downward deflection of the stabilizer
        b. The tail surface is producing less down load, relieving the wing of loading and lift required to maintain altitude
            - Results in a lower stall speed
        c. Recovery from a stall becomes progressively more difficult as the CG moves aft
            - Moving the CG aft shortens the arm from the elevator, reducing the amount of force it can apply
    iii. A forward loaded aircraft is closer to the critical angle of attack but also has more control due to the long moment arm from the elevator to the forward CG
    iv. An aft loaded aircraft flies at a lower pitch attitude and therefore farther away from the critical AOA, but will have less control in the case of a power-off stall
H. Aircraft Attitude
    i. A change in attitude is simply a change in the aircraft's position in space. Everything else remaining the same, all of the factors will have some effect on the aircraft's attitude and most likely will result in an increase or decrease in pitch
I. Yaw Effects
    i. Torque (the left turning tendency of the aircraft) is made up of 4 elements which produce a twisting axis around at least 1 of the aircraft's 3 axes
        a. Torque Reaction, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Prop, and P-Factor
    ii. Torque Reaction



        a. Although torque reaction is more of a rolling tendency than a yaw effect, it does c the left turning tendencies of the aircraft
        b. Newton's 3rd Law – For every action there is an equal and opposite reaction
            - The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction
        c. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency
        d. On the ground, during takeoff, the left side is being forced down resulting in more ground friction
            - This causes a turning moment to the left that is corrected with rudder
                a Strength is dependent on engine size/hp, propeller size/rpm, plane size and ground surface

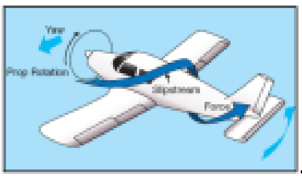
1. The higher the power setting, the greater the left turning tendency

iii. Torque is corrected by offsetting the engine, and using aileron trim tabs, and aileron/rudder use
- Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset in order to counteract a portion of the rolling motion caused by torque
- Trim tabs can be adjusted to counter the turning tendency in level flight
- Torque that is not countered by the engine and trim tab position must be corrected with coordinate rudder and aileron inputs

iv. Corkscrew/Slipstream Effect

a. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft
- The 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 very compact



- This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
- The corkscrew flow also creates a rolling moment around the longitudinal axis
  - a The rolling moment is to the right and may counteract torque to an extent

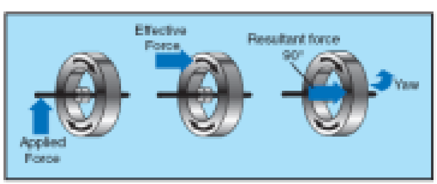
As the forward speed increases, the spiral elongates and becomes less effective

d. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in climbs (high prop speed and low forward speed)

e. In relation to slow flight, the high propeller speed and low forward speed results in a relatively pronounced slipstream effect which should be countered with right rudder, and aileron as necessary

v. 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
    2. Ex: This most often occurs with tail wheel aircraft when the tail is being 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
   i. This force is felt 90° in the direction of rotation (clockwise as viewed from the cockpit)

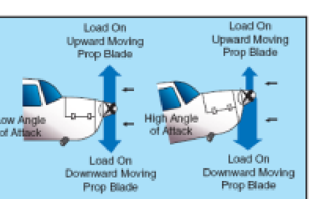
b. The forward force will take effect on the Right side of the propeller, yawing the aircraft Left

b. In relation to slow flight, lifting the nose would result in a left yawing motion on the aircraft
- Any yawing around the vertical axis results in a pitching moment
- Any pitching around the lateral axis results in a yawing moment
- Correction is made with necessary elevator and rudder pressures

vi. Asymmetric Loading (P Factor)

a. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade
- This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)

b. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc



- At positive AOA, the right blade is passing through an area of resultant velocity greater than the left
- Since the prop is an airfoil, increased velocity means increased lift
    - a Therefore, the down blade has more lift and tends to yaw the plane to the left

c. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)
- If there were no air movement at all, except that generated by the prop, identical sections of the blade would have the same airspeed
- 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
    - a The blade proceeding is creating more lift or thrust, moving the center of lift toward it
- Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
    - a The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow

d. Summary: The descending blade of the propeller 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 the aircraft will have a tendency to yaw to the left

e. 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

vii. Yaw Effects and the Power-Off Stall

a. During the low power settings associated with the power-off stall, very little (if any) right rudder is required to maintain coordinated flight

b. During the recovery from the stall, when the power is increased to max it is essential the pilot uses right rudder to maintain coordination
- The amount of rudder necessary can be learned through experience, but it most cases it is similar to the rudder required during takeoff
- Smoothly, but deliberately increase power and right rudder together to maintain coordination

J. Configuration

i. In the case of configuration changes, we'll look simply at flaps and the gear

a. Flaps
- When the flaps are lowered the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
    - a For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
- Flaps also result in additional drag due to the increased lift and additional surface area protruding into the wind
- Adding flaps can change the AOA, airspeed, and attitude of the aircraft
    - a As mentioned above, the AOA changes since flaps are designed to influence the AOA
    - b The airspeed will decrease due to the additional drag, and therefore power will have to be increased to maintain the same speed
    - c Attitude will change due to the changing configuration, and AOA

b. Gear
- In the case you have retractable gear, lowering the gear will result in additional drag and in some cases it may affect the pitch of the aircraft and therefore make a small change to the AOA
- As gear is lowered, additional power is required to maintain airspeed and in the case that the gear does have an effect on the AOA, the pitch/attitude will have to be adjusted to compensate

2. **Stall Characteristics and Impending Stall and Full Stall Indications**
   A. Stall Characteristics
      i. Most wings are designed to stall progressively outward from root to tip
         a. This is done by designing the wings with *washout* - the wingtips have less angle of incidence (AOI) than the wing roots
            - AOI - Angle between the chord line of the wing and longitudinal axis of the airplane
            - This design allows the tips of the wings to have a lower AOA than the wing roots
         b. This is done so the ailerons are still effective at high AOA's and the plane has more stable stalling characteristics
   B. Approach to Stall Indications
      i. A good technique is to announce the Indications as you recognize them
         a. Stall Warning Horn
         b. Reduced Control Effectiveness
         c. Buffet
         d. Stall
      ii. Sight
         a. Attitude of the airplane
            - Increasing pitch attitude
      iii. Sound
         a. Stall warning horn
         b. Ambient noise will tend to decrease with airspeed and the lessening flow of air around the aircraft
      iv. Kinesthesia (The sensing of changes in direction or speed of motion)
         a. Probably the most important and best indicator to the trained pilot
         b. If developed, it will warn of a decrease in airspeed or the beginning of the airplane settling/mushing
      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
   C. Full Stall Indications (Power Off Stalls)
      i. Because of design variations, the stall characteristics for all aircraft can't be specifically described; however, the most notable indications for small general aviation aircraft are the elevator control position (full back, against the stops) and a high descent rate
         a. A full stall in some aircraft is relatively gentle, whereas others may have a tendency to 'bite' in one direction or another. Be aware of the characteristics of your aircraft.
3. **Factors and Situations that can Lead to a Power-Off Stall and Actions that can be Taken to Prevent it**
   A. The power off stall is meant to simulate a stall during approach to landing or during the landing itself
   B. Possible Situations and Actions to Prevent the Stall
      i. Crossed-control turns from base to final
         a. Always maintain coordination, especially close to the ground, in the pattern
         b. Do not use rudder above what is required to keep the aircraft coordinated when making turns
            - For example, additional rudder to prevent overshooting a runway can lead to a cross-controlled situation which can lead to a cross controlled stall. Initiate a go around if necessary, don't cross control the aircraft

ii. High bank angles at low airspeeds often associated with the traffic pattern
    a. High bank angles combined with too much back pressure can result in high G-loading and lead to a stall
    b. Limit bank in the pattern to a maximum of 30 degrees
        - Do not use extra rudder to help the aircraft around a turn
            a For example, if more than 30 degrees of turn is required to line up on final, don't establish 30 degrees of bank and add additional rudder (beyond what is necessary to be coordinated) to help the aircraft around the turn. This is just as dangerous (cross control stall), if not more dangerous than using high bank angles close to the ground

iii. Attempting to recover from a high sink rate without using a combination of pitch and power
    a. Just pitching can quickly slow and stall the aircraft resulting in a further increased sink rate
    b. Use a combination of pitch and power to maintain airspeed and glidepath
        - A pitch up tends to need an increase in power to maintain airspeed and vice versa, an increase in power requires an increase in pitch to maintain speed
        - A pitch down tends to need a decrease in power to maintain airspeed, and a decrease in power requires a decrease in pitch to maintain airspeed
        - A stable approach, on speed and glidepath is a safe approach. In the case of an unstable approach execute a go around and set up the approach again

iv. Improper airspeed control on final and other segments of the pattern
    a. In most aircraft, the pilot will pitch for airspeed and use power to control glideslope on the approach
        - As mentioned above, changes in pitch require changes in power to maintain airspeed and the glidepath. Adjust them together to maintain a stable approach on final.

v. Trying to stretch a glide
    a. A glide is performed at the best glide speed. Descending at any speed other than the best glide speed reduces the distance the aircraft will travel.
    b. By trying to stretch a glide, the aircraft is pitched up and therefore slows since power cannot be added to compensate. As the aircraft slows, the aircraft descends at a higher rate (slower airspeed = less lift). The natural reaction to an increasing sink rate (the ground coming at you faster) is to attempt to climb by raising the nose. This further slows the aircraft and increases the rate of descent and will likely result in a power-off stall
        - Never try to stretch a glide. The best glide speed is the speed at which the aircraft will glide the furthest. Using a higher or slower speed will reduce the glide ability of the aircraft
            a As uncomfortable as it may be, do not increase pitch to stretch a glide as it will shorten the glide

4. Fundamentals of Stall Recovery

A. Recovering from a Power-Off Stall
    i. First, the pitch attitude and angle of attack must be decreased positively and immediately
        a. Since the basic cause of a stall is always an excessive angle of attack (AOA) the cause must be eliminated
        b. This lowers the wing to an effective AOA
            - The object is to reduce the AOA but only enough to allow the wing to regain lift
                a Reduce the AOA, then adjust the pitch attitude to the desired climb attitude (V_Y)
                b Avoid a Secondary stall - Don't rush the recovery to level flight or a climb
                    1. An aggressive pitch to regain climb speed can lead to another excessive AOA
    ii. Second, maximum allowable power should be applied to increase airspeed and help reduce the AOA
        a. Power is not essential to stall recovery, reducing the AOA is the only way of recovering

b. In a power-off stall, power is essential to establishing a climb and gaining altitude
c. As power is advanced, right rudder will be necessary to maintain coordination

iii. Third, maintain directional control with coordinated use of aileron and rudder and climb out at V_Y
    a. If the wings were not level, use coordinated aileron and rudder to return to straight flight

B. Ailerons and Recovery
    i. Most general aviation aircraft wings are designed to stall progressively outward from the wing root
        a. 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
        b. During the recovery, the return of lift begins at the tips and progresses towards the roots
            - Thus, ailerons can be used to level the wings
    ii. If the wing is fully stalled (ailerons included), using the ailerons can result in an aggravated stall condition
        a. 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
            - Increasing the AOA on an already stalled wing will aggravate the stall on that wing
            - The increase in drag and aggravated stall on one wing will yaw the aircraft in the direction of the wing and could result in a spin

C. Rudder and Recovery
    i. Even if excessive aileron was applied, a spin won't occur if yaw is maintained by rudder pressure, therefore it is important that the rudder be used properly during the entry and recovery
    ii. The primary use of rudder is to counteract any tendency of the airplane to yaw or slip
    iii. Maintaining coordinated directional control with the rudder is vital in avoiding a spin

D. Common Errors During Recovery
    i. Excessive altitude loss or excessive airspeed during recovery
        a. Only lower the nose enough to break the stall, after the stall is broken establish a climb
        b. Excessive speeds and nose low attitudes close to the ground are extremely hazardous
    ii. Poor stall recognition and delayed recovery
        a. Do not delay recovery, recover at the first indication of stall (unless required otherwise by the PTS for training purposes) - At slow airspeeds, in a descent, close to the ground any delay could be hazardous
    iii. Secondary stall during recovery
        a. Once the stall is broken, do not aggressively lift the nose to reestablish a climb as this can quickly result in a secondary stall
        b. Use smooth, controlled inputs monitoring the aircraft's performance to ensure it is ready to climb
    iv. Rough and/or uncoordinated use of the flight controls
        a. Just like in slow flight, use smooth movements in controlling the airplane, nothing jerky
        b. A smooth controlled recovery is the goal, this will also help to avoid a secondary stall

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Factors and Situations that can Lead to a Power-Off Stall and Actions that can be Taken to Prevent it

A. See Part 3, above

2. Range and Limitations of Stall Warning Indicators

A. Stall Warning Horn

    - i. The stall warning horn usually comes on 4-8 knots prior to the stall onset to provide warning and time for recovery
        - a. Reference the POH for more specifics on the stall warning horn installed on your aircraft in regards to its range and limitations
- B. Buffet
    - i. In the case the aircraft is not recovered after the stall warning horn, buffeting or vibrations may begin just prior to the stall
- C. Understanding the signs of an impending stall is extremely important
    - i. Not being familiar with these indications can result in a dangerous situation, especially if your stall warning indicator has limitations you are unaware of

3. Failure to Recognize and Recover at the Stall Warning during Normal Operations

- A. Deeper Stall
    - i. The longer it takes the pilot to recognize and recover from the stall, the deeper the stall can become resulting in a greater loss of altitude and more difficult time recovering the aircraft
- B. Recover from a stall at the first indication of the stall whether that's a feeling of sinking or mushy controls, the stall warning horn, or aircraft buffet. The sooner the pilot recovers, the safer the situation

4. Improper Stall Recovery Technique

- A. Failure to reduce the AOA
    - i. Without reducing the AOA, the aircraft will remain in a stall and altitude will continue to decrease
        - a. Since the basic cause of a stall is always an excessive angle of attack (AOA) the cause must be eliminated
- B. Failure to use max power
    - i. The primary consequence of not max performing is an increased loss of altitude, or a secondary stall
        - a. The stall can be broken by decreasing the AOA, but without power the aircraft will not be able to climb.
            - In the case a climb is attempted without power, the pilot can quickly put the aircraft into a secondary stall
    - ii. Power is essential to regaining airspeed (without losing altitude) and establishing a climb or at least level flight
- C. Failure to use coordinated aileron and rudder to return to straight flight
    - i. Stall + Uncoordinated Yaw = Spin. Worst case, an uncoordinated recovery can induce a stall
        - a. Maintain coordinated flight during all stall recoveries to prevent spinning the aircraft
    - ii. Best case, straight and level flight is regained but at the cost of additional drag due to the uncoordinated flight
        - a. This leads to decreased performance, likely resulting in additional altitude lost

5. Secondary Stalls, Accelerated Stalls, and Cross-Control Stalls

- A. Secondary Stall
    - i. A secondary stall occurs after recovery from a preceding stall
        - a. It is often caused:
            - By attempting to hasten the completion of a stall recovery before the aircraft has regained sufficient flying speed
            - By the pilot using abrupt control input to return to straight and level flight
            - When the pilot fails to reduce the AOA sufficiently during stall recovering
            - When the pilot attempts to break the stall using power only
    - ii. Recovery
        - a. Release back elevator pressure just like in a normal stall recovery
        - b. Increase the power to max

c. When sufficient airspeed has been regained, the airplane then can be returned to straight and level flight

B. Accelerated Stall
   i. The airplane will stall at a higher indicated airspeed when excessive maneuvering loads are imposed on it
   ii. Possible Situations
      a. Steep turns, stall and spin recoveries, steep pull ups, or other abrupt changes in the aircraft's flightpath
      b. The AOA may exceed the critical angle while recovering from a steep descent too sharply
         - The relative wind may be aligned with the descent angle causing an almost level pitch attitude stall
      c. The aircraft will stall during a coordinated steep turn exactly as it does from straight and level flight, except the pitching and rolling actions tend to be more sudden
         - Slipping - Tends to roll rapidly toward the outside of the turn (Outside wing stalls 1^{st})
         - Skidding - Tends to roll rapidly toward the inside of the turn (Inside wing stalls 1^{st})
         - Coordinated - Both wings stall simultaneously, just like straight and level
   iii. Accelerated Stalls tend to be more rapid/severe as they occur at higher airspeeds and lower than normal pitch attitudes
   iv. Hazards of Accelerated Stalls
      a. Significant load factor increases can be imposed when pulling out of steep dives or in steep turns
         - This can result in structural damage due to the excessive loads on the airplane (Stay below V_A)
   v. Recognizing the Stall
      a. High sink rate, nose-down pitching, extremely negative load factor, loss of control effectiveness
      b. Buffet, stall warning horn will indicate an impending stall
         - The normal nose high attitude and reduction in noise as the aircraft slows does not occur in accelerated stalls
   vi. Recovery
      a. The elevator pressure should be released and power increased to break the stall (normal recovery)
      b. If uncoordinated, one wing may drop suddenly
         - Recover by releasing excessive back pressure, adding power, and using coordinated control pressures

C. Cross-Control Stall
   i. The type of stall occurs with the controls crossed – aileron pressure applied in one direction and rudder pressure in the opposite direction. When excessive back pressure is applied, a cross-control stall may result
   ii. Common Situations
      a. A poorly planned and executed base-to-final approach turn, and often is the result of overshooting the centerline of the runway during that turn
         - Normally, the proper action to correct for overshooting the runway is to increase the rate of turn with coordinated rudder and aileron, but a pilot may limit his or her bank in the pattern during an overshoot and attempt to increase the rate of turn by adding more rudder pressure than required
         - The addition of inside rudder pressure causes the speed of the outer wing to increase, creating greater lift on that wing, and will also lower the nose

        a To keep the wing from rising, and maintain a constant bank angle, opposite aileron is required
        b To adjust for the lowered nose, increased back pressure is necessary
        c The resulting condition is a turn with rudder in one direction, aileron in the opposite direction and excessive back elevator pressure
    - The wing on the outside of the turn speeds up and produces more lift than the inside wing; thus, the aircraft increases bank. The down aileron on the inside of the turn helps drag that wing back, slowing it up and decreasing its lift, which requires more aileron application. This further causes the aircraft to roll.
        a The roll may be so fast that it is possible the bank will be vertical or past vertical before it is stopped.

b. Recognizing the Stall
    - Be aware of the cross-controlled situation
        a Do not use excessive rudder to increase the rate of turn

c. Recovery from the Stall
    - Recovery must be made before the aircraft enters an abnormal attitude (vertical spiral or spin)
    - It is a simple matter to return to straight-and-level flight by coordinated use of the controls
    - The pilot must be able to recognize when this stall is imminent and must take immediate action to prevent a completely stalled condition. It is imperative this type of stall not occur during an actual approach to a landing, since recovery may not be possible prior to ground contact due to the low altitude

6. Effect of Environmental Elements on Aircraft Performance

A. Turbulence
  i. When flying more slowly than minimum drag speed (LD/MAX) the aircraft will exhibit a characteristic know as speed instability
    a. If the aircraft is disturbed by even the slightest turbulence, the airspeed will decrease. As airspeed decreases, the total drag also increases resulting in further loss in airspeed. The total drag continues to rise and speed continues to fall
      - Unless more power is applied and/or the nose is lowered, the speed will continue to decay right down to the stall
  ii. The pilot must understand that, at speed less than minimum drag speed, the airspeed is unstable and will continue to decay if allowed to do so

B. Microbursts
  i. A strong downdraft which normally occurs over horizontal distances of 1 NM or less and vertical distances of less than 1,000'. In spite of its small horizontal scale, an intense microburst could induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm.
  ii. In a situation such as an approach to landing, when the aircraft is in a high angle of attack, and slow airspeed, there is minimal ability for the aircraft to climb, especially in the case of a microburst
    a. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common. In the case of a microburst, recover from slow flight and establish the best climb configuration and climb airspeed for your aircraft
  iii. The FAA has developed a Pilot Windshear Guide Advisory Circular (AC 00-54)
    a. Included is information on how to recognize the risk of a microburst encounter, how to avoid an encounter and the best flight strategy for successful escape should an encounter occur

C. Density Altitude
  i. Pressure Altitude

a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
    - $1{,}000(29.92 - \text{Alt}) + \text{Elev}$

b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
    - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
    - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather

ii. Density Altitude/Temperature

a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
    - $120(°\text{C} - 15°\text{C}) + \text{PA}$ (this is an approximation)

b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
    - Lower temperatures (the air is more compressed) result in better performance
    - Higher temperatures (the air is less compressed) result in poorer performance
    - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
        - a Lower temperatures result in better performance
        - b Overall, high pressure, cold days result in the best performance

iii. Humidity

a. Although not directly accounted for on the performance charts, humidity decreases performance

iv. In relation to power-off stalls, the aircraft will perform better in lower pressure and density altitudes as well as with lower amounts of humidity and will perform worse in the opposite conditions

a. Therefore, the aircraft will have a more difficult time maintaining airspeed and altitude in poorer atmospheric conditions

7. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Minimum Altitudes for the Power-Off Stall Maneuver

i. Single Engine Aircraft

a. Complete the maneuver no lower than 1,500' AGL. This is because an average spin rotation in a single engine aircraft takes approximately 500' of altitude. This minimum altitude allows for recovery from a spin within two turns + 500' (3 full rotations before reaching the ground)

ii. Multi Engine Aircraft

a. Complete the maneuver no lower than 3,000' AGL. This is because an average spin rotation in a multi engine aircraft takes approximately 1,000' of altitude. This minimum altitude allows for recovery from a spin within two turns + 1,000' (3 full rotations before reaching the ground)

B. Collision Avoidance

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
  - a A balloon has the right of way over any other category
  - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
  - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
  - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
- Each pilot shall alter course to the right

d. Overtaking
- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
  - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
  - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
- 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
- This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
- Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

C. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
        - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

D. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
        - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires
    a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
    b. These wires and lines may or may not be lighted
    c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
    a. Ensure proper clearance between the aircraft and obstacle
        - If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

8. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. During power-off stalls, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
    a. Flying takes precedence
        - Aviate, Navigate, Communicate
        - In the case of a real-life power-off stall recovery, it is essential the pilot safely recover the aircraft

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important when operating in the pattern and in configurations associated with power-off stalls. A loss of situational awareness can lead to a power-off stall, mishaps, or incursions on the ground or in the air
   i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   ii. Maintain situational awareness
       a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
   i. Attention needs to be divided between the various required tasks
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
         - By effectively dividing attention, the pilot can deter the chance of a power-off stall
      b. Safety is your number one priority
         - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
       a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, 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
           a Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL) or 3,000 feet AGL (AMEL).
3. Configure the airplane in the approach or landing configuration, as specified by the evaluator, and maintain coordinated flight throughout the maneuver.
4. Establish a stabilized descent.
5. Transition smoothly from the approach or landing attitude to a pitch attitude that will induce a stall.
6. Maintain a specified heading, ±10 if in straight flight; maintain a specified angle of bank not to exceed 20°, ±10°, if in turning flight, while inducing the stall.
7. Acknowledge cues of the impending stall and then recover promptly after a full stall occurs.
8. Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
9. Configure the aircraft as recommended by the manufacturer and accelerate to V_X or V_Y.
10. Return to the altitude, heading, and airspeed specified by the evaluator.

VII.C. Power-On Stalls

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Stall and Spin Awareness Training (AC 61-67), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Aerodynamics Associated with Slow Flight in Various Aircraft Configurations, to include the Relationship Between:**
   - A. Stall Aerodynamics
     - i. A stall occurs when the smooth airflow over the wing is disrupted and lift decreases rapidly
       - a. This is caused when the wing exceeds its critical angle of attack (AOA)
       - b. This can occur at any airspeed, in any attitude, with any power setting
     - ii. More Specifically…
       - a. When the AOA is increased to approximately 15°-20° (usually 18°) the air can't follow the upper curvature of the wing
         - This is the critical AOA: the angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight
       - b. As the critical AOA is approached, the air begins separating from the rear of the upper wing surface
         - As the AOA is further increased, the airstream is forced to flow straight back
           - a This causes a swirling/burbling of air attempting to flow over the upper surface
         - When the critical AOA is reached, the turbulent airflow spreads over the entire upper wing
           - a This results in a sudden increase in pressure on the upper surface and a decrease in lift
             1. Due to the loss of lift and the increase in form drag (large area of the wing/fuselage is exposed to the turbulent airstream) the remaining lift can't support the plane and the wing stalls
   - B. Angle of Attack (AOA)
     - i. Defined: The acute angle between the chord line of the airfoil and the direction of the relative wind
       - a. As the airspeed slows, the angle between the chord line and the relative wind increases (assuming everything else remains the same)
         - For example, imagine straight and level flight at 100 knots. As the aircraft slows to 60 knots, in order to maintain straight and level flight, the nose must be raised (the lift lost due to the decreasing airspeed is replaced by increasing the angle of attack). Therefore, the relative wind remains the same (the aircraft is still straight and level), but the angle of attack is considerably higher than at 100 knots.
       - b. Critical Angle of Attack: The angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight
     - ii. AOA and Airspeed
       - a. As mentioned above, decreasing airspeed necessitates an increasing AOA to maintain lift and vice versa (increasing airspeed, requires a decreasing angle of attack to maintain the same amount of lift)
       - b. When the aircraft slows enough and reaches the critical angle of attack the aircraft will stall
     - iii. AOA and Load Factors
       - a. As the load factor ("weight") increases, the AOA must be increased to compensate for the additional weight and the opposite applies (less load factor = less AOA)

b. Increased load factor results in an increased AOA which can lead to exceeding the critical angle of attack and a stall

iv. AOA and Configuration

a. When the flaps are lowered, the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude

- For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
- The aircraft now has a lower AOA than with the flaps retracted, the lower AOA means there is a greater distance between the aircraft's AOA and the critical AOA and therefore the aircraft will stall at a slower airspeed

v. AOA and Weight

a. Increased weight results in an increased AOA to maintain altitude. The heavier the plane the more lift required and vice versa

b. The heavier the aircraft, the closer the AOA is to the critical angle of attack and easier it is to stall

vi. AOA and Attitude

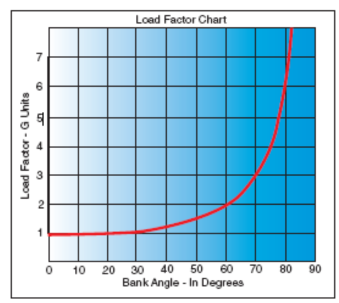
a. Changing the AOA usually is a direct change in the aircraft attitude, specifically the pitch of the aircraft

C. Airspeed

i. An increase or decrease in airspeed increases or decreases lift and thus can have an effect on AOA and the attitude of the aircraft

a. AOA would have to increase with a loss of airspeed and vice versa

D. Load Factor



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

a. Expressed in terms of G's

ii. Turns

a. Increased load factors are a characteristic of all banked turns

b. Load factor increases at a high rate after 45°-50° of bank

iii. An increased load factor effectively increases the weight of the aircraft during the time that the load factor is imposed

a. For example, in cruise flight an aircraft may be at 1 G and weigh 2,000 lbs. In a 60-degree banked turn holding altitude the aircraft is at 2 G's and effectively has increased its weight to 4,000 lbs. while at 2 G's

b. The increased load factor requires a higher AOA or airspeed or both to compensate for the additional load during the maneuver

iv. An increase or decrease in the load factor effectively increases or decreases the weight of the aircraft and thus can affect the AOA, airspeed, weight, and attitude of the aircraft

a. An increased load factor effectively makes the aircraft seem heavier to the flight controls and therefore, to maintain altitude the AOA would have to be increased to generate the additional lift required

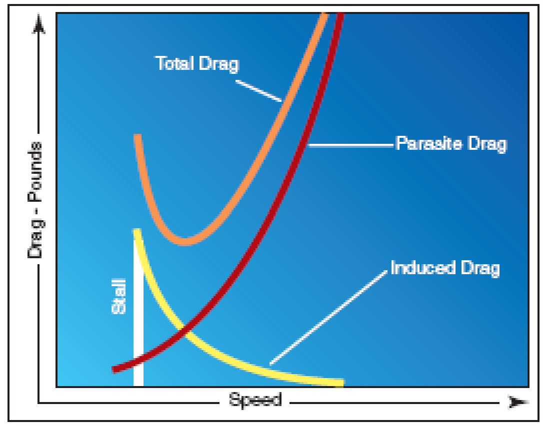
b. An increased load factor could also be compensated for by increasing the airspeed

- This would generate additional lift to compensate for the "increased weight" and thus allow the AOA to stay the same

v. In relation to power-on stalls, the higher the load factor, the higher the stall speed due to the higher AOA required

E. Power Setting

i. It is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed
   a. As airspeed decreases from cruise to L/D_{MAX}, total drag and thrust required decrease to maintain a constant altitude
   b. As airspeed decreases below L/D_{MAX}, additional power (thrust) is required to maintain a constant altitude



      - Total drag is now increasing because induced drag increases faster (due to higher the angle of attack) than parasite drag decreases
      - This is known as the 'backside of the power curve' or the 'region of reverse command'
         a The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude

ii. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components
   a. In slow flight (which can often lead to a power-off stall), thrust no longer acts parallel to and opposite to the flight path and drag.
      - In slow flight, thrust has two components:
         a One acting perpendicular to the flight path in the direction of lift
         b One acting along the flight path
   b. Because the actual thrust is inclined, its magnitude must be greater than drag if its component acting along the flight path is equal to drag
      - The forces acting upward (wing lift and the component of thrust) equal the forces acting downward (weight and tail down force)
   c. Wing loading is actually less during slow flight because the vertical component of thrust helps support the airplane

iii. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over them
   a. As airspeed decreases, control effectiveness decreases disproportionately
      - There is a loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed, but there is a considerably greater loss as the airspeed is reduced to 10 knots above the stall speed
   b. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high power setting condition
   c. Large control movements may be required
   d. This does not mean rough or jerky movements

iv. In relation to a power-on stall, during takeoff or climb, appropriate pitch and power settings should be used to maintain a stable climb speed and path
   a. Deviating from a stable climb can result in a stall
   b. Since power may already be at max, decreasing the AOA may be the only effective way of recovering from a power-on stall

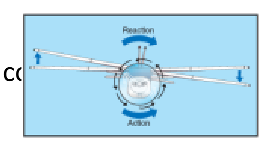
F. Aircraft Weight

  i. An increase in weight is similar to an increase in load factor, except that the increased weight exists throughout the entire flight, rather than during the specific maneuver that will change the aircraft's load factor (G's)
    a. Increasing weight requires an increased AOA or airspeed to compensate for the additional lift required
  ii. Increased weight can lead to a power-on stall at higher airspeeds due to the higher AOA required

G. Center of Gravity
  i. An airplane with forward loading
    a. The aircraft acts heavier, and consequently slower than the same airplane with a further aft CG
      - Nose up trim is required which requires the tail surfaces to produce a greater download which adds to the wing loading and the total lift required to maintain altitude
    b. Requires a higher angle of attack, resulting in more drag and a higher stall speed
    c. The aircraft is more controllable though
      - This is due to the longer arm from the elevator to the CG
  ii. With aft loading (aircraft acts lighter), the airplane requires less download allowing for a faster cruise speed
    a. Faster cruise because of reduced drag
      - Reduced drag is a result of a smaller angle of attack and less downward deflection of the stabilizer
    b. The tail surface is producing less down load, relieving the wing of loading and lift required to maintain altitude
      - Results in a lower stall speed
    c. Recovery from a stall becomes progressively more difficult as the CG moves aft
      - Moving the CG aft shortens the arm from the elevator, reducing the amount of force it can apply
  iii. A forward loaded aircraft is closer to the critical angle of attack but also has more control due to the long moment arm from the elevator to the forward CG
  iv. An aft loaded aircraft flies at a lower pitch attitude and therefore farther away from the critical AOA, but will have less control in the case of a power-on stall

H. Aircraft Attitude
  i. A change in attitude is simply a change in the aircraft's position in space. Everything else remaining the same, all of the factors will have some effect on the aircraft's attitude and most likely will result in an increase or decrease in pitch

I. Yaw Effects
  i. Torque (the left turning tendency of the aircraft) is made up of 4 elements which produce a twisting axis around at least 1 of the aircraft's 3 axes
    a. Torque Reaction, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Prop, and P-Factor
  ii. Torque Reaction



    a. Although torque reaction is more of a rolling tendency than a yaw effect, it does co the left turning tendencies of the aircraft
    b. Newton's 3rd Law – For every action there is an equal and opposite reaction
      - The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction
    c. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency
    d. On the ground, during takeoff, the left side is being forced down resulting in more ground friction

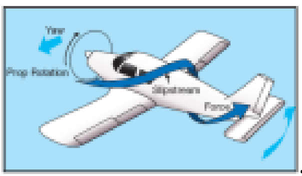
- This causes a turning moment to the left that is corrected with rudder
  - a Strength is dependent on engine size/hp, propeller size/rpm, plane size and ground surface
    1. The higher the power setting, the greater the left turning tendency

iii. Torque is corrected by offsetting the engine, and using aileron trim tabs, and aileron/rudder use
- Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset in order to counteract a portion of the rolling motion caused by torque
- Trim tabs can be adjusted to counter the turning tendency in level flight
- Torque that is not countered by the engine and trim tab position must be corrected with coordinate rudder and aileron inputs

iv. Corkscrew/Slipstream Effect

a. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft
- The 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 very compact



- This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
- The corkscrew flow also creates a rolling moment around the longitudinal axis
  - a The rolling moment is to the right and may counteract torque to an extent

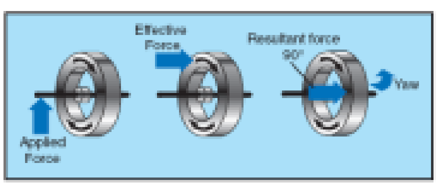
. As the forward speed increases, the spiral elongates and becomes less effective

d. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in climbs (high prop speed and low forward speed)

e. In relation to slow flight, such as during a takeoff climb, the high propeller speed and low forward speed results in a relatively pronounced slipstream effect which should be countered with right rudder, and aileron as necessary

v. 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
    2. Ex: This most often occurs with tail wheel aircraft when the tail is being 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

i. This force is felt 90° in the direction of rotation (clockwise as viewed from the cockpit)

b. The forward force will take effect on the Right side of the propeller, yawing the aircraft Left

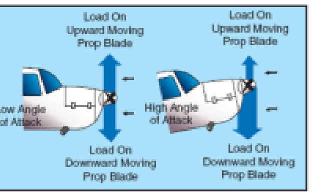
b. In relation to slow flight, lifting the nose would result in a left yawing motion on the aircraft
- Any yawing around the vertical axis results in a pitching moment
- Any pitching around the lateral axis results in a yawing moment
- Correction is made with necessary elevator and rudder pressures

vi. Asymmetric Loading (P Factor)

a. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade

- This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)

b. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc



- At positive AOA, the right blade is passing through an area of resultant velocity greater than the left
- Since the prop is an airfoil, increased velocity means increased lift
    - a Therefore, the down blade has more lift and tends to yaw the plane to the left

c. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)

- If there were no air movement at all, except that generated by the prop, identical sections of the blade would have the same airspeed
- 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
    - a The blade proceeding is creating more lift or thrust, moving the center of lift toward it
- Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
    - a The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow

d. Summary: The descending blade of the propeller 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 the aircraft will have a tendency to yaw to the left

e. 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

vii. Yaw Effects and the Power-On Stall

a. During the high-power settings and high AOA associated with the power-on stall, considerable right rudder is required to maintain coordinated flight

- The amount of rudder necessary can be learned through experience, but it most cases it is similar to the rudder required during takeoff
- If not at max power during the recovery, smoothly, but deliberately increase power and right rudder together to maintain coordination

J. Configuration

i. In the case of configuration changes, we'll look simply at flaps and the gear

a. Flaps

- When the flaps are lowered the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
    - a For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
- Flaps also result in additional drag due to the increased lift and additional surface area protruding into the wind
- Adding flaps can change the AOA, airspeed, and attitude of the aircraft
    - a As mentioned above, the AOA changes since flaps are designed to influence the AOA
    - b The airspeed will decrease due to the additional drag, and therefore power will have to be increased to maintain the same speed
    - c Attitude will change due to the changing configuration, and AOA

b. Gear

- In the case you have retractable gear, lowering the gear will result in additional drag and in some cases, it may affect the pitch of the aircraft and therefore make a small change to the AOA

- As gear is lowered, additional power is required to maintain airspeed and in the case that the gear does have an effect on the AOA, the pitch/attitude will have to be adjusted to compensate

2. Stall Characteristics and Impending Stall and Full Stall Indications

A. Stall Characteristics
  i. Most wings are designed to stall progressively outward from root to tip
    a. This is done by designing the wings with *washout* - the wingtips have less angle of incidence (AOI) than the wing roots
      - AOI - Angle between the chord line of the wing and longitudinal axis of the airplane
      - This design allows the tips of the wings to have a lower AOA than the wing roots
    b. This is done so the ailerons are still effective at high AOA's and the plane has more stable stalling characteristics

B. Approach to Stall Indications
  i. A good technique is to announce the Indications as you recognize them
    a. Stall Warning Horn
    b. Reduced Control Effectiveness
    c. Buffet
    d. Stall
  ii. Sight
    a. Attitude of the airplane
      - Increasing pitch attitude
  iii. Sound
    a. Stall warning horn
    b. Ambient noise will tend to decrease with airspeed and the decreasing flow of air around the aircraft
  iv. Kinesthesia (The sensing of changes in direction or speed of motion)
    a. Probably the most important and best indicator to the trained pilot
    b. If developed, it will warn of a decrease in airspeed or the beginning of the airplane settling/mushing
  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

C. Full Stall Indications (Power On Stalls)
  i. Because of design variations, the stall characteristics for all aircraft can't be specifically described; however, the most notable indications for small general aviation aircraft are the elevator control position (full back, against the stops) and a high descent rate
    a. Usually a power-on stall is more noticeable than a power-off stall. Whereas some aircraft may gently stall with the power off, often a wing will drop during a power-on stall
    b. A full stall in some aircraft is relatively gentle, whereas others may have a tendency to 'bite' in one direction or another. Be aware of the characteristics of your aircraft.

3. Factors and Situations that can Lead to a Power-On Stall and Actions that can be Taken to Prevent it

A. The power on stall is meant to simulate a stall during the takeoff, climb, or go around phase of flight

B. Possible Situations and Actions to Prevent the Stall
  i. Takeoff/Climbs

a. Distractions during the takeoff/climb phase can lead to a power-on stall
  - If airspeed and/or pitch attitude are neglected the aircraft could end up in an excessively nose high pitch attitude with decreasing airspeed and an impending stall
  - Maintain a crosscheck of the aircraft instruments, while handling other required tasks (communicating with ATC, navigating, etc.)
  - Be familiar with the approximate pitch attitude for the desired climb speed
    - a The pitch attitude may vary based on conditions and weight, but use the approximate pitch attitude and make small adjustments to obtain the desired speed

ii. Go Arounds
  a. Excessive pitch attitudes or forgetting to add power during the go around can result in an inadvertent stall or spin
  - Excessive Pitch Attitudes
    - a Excessive back pressure: If the pilot were to use excessive/aggressive back pressure to initiate a go around the aircraft could quickly reach a stalled condition
      1. Smoothly and deliberately increase back pressure to establish a climb pitch attitude while increasing power (and increasing right rudder to compensate)
  - Go-around without power
    - a A go around without power can quickly transition to a power-off stall
    - b Increase pitch and power, using rudder to maintain coordination

iii. Takeoffs
  a. Abrupt pitch control inputs can lead to power-on stalls during takeoff/departure
  - Use smooth, but positive control movements
  - Know the approximate pitch attitude required for takeoff and the takeoff climb. Establish this attitude and make small adjustments to fine tune the airspeed

  b. Short Field Takeoff
  - Due to the shortened runway length, excessive or abrupt pitch attitudes to avoid an obstacle or get the aircraft airborne quickly can result in an inadvertent stall

  c. Use smooth, but positive control inputs

4. Fundamentals of Stall Recovery

A. Recovery Procedure
  i. Release back pressure
    a. Lower the nose as necessary to regain flying speed with minimum loss of altitude
  ii. Smoothly advance the throttle to maximum allowable power (if not already there)
    a. Since the throttle is already at a climb power setting, the additional power will be slight
    b. As power is increased, additional right rudder may be necessary to maintain coordination
  iii. Return to straight flight
    a. Using coordinated aileron and rudder, return the aircraft to a wings level condition
  iv. Raise the nose to a climb attitude, when sufficient altitude is regained, return to level flight and a cruise power setting

B. The Most Efficient Recovery
  i. The most efficient recovery procedure is the one in which the least amount of altitude is lost
  ii. This will vary based on configuration
    a. Follow the manufacturer's procedures in the POH
  iii. It often is not necessary to lower the nose to the same pitch attitude required in a power-off stall. This is due to the power setting creating airflow over the wings and the relatively high pitch attitudes associated with a power-on stall.

        a. For example, if the stall occurs near 15 or 20 degrees nose high during a power-on stall, the nose may only need to be lowered to 5 degrees or so to recover from the stall and reestablish a climb
        b. By recovering at a higher AOA less altitude is lost
            - This will, of course, vary by aircraft and isn't a set rule. Know what works for your aircraft
C. Ailerons and Recovery
    i. Most general aviation aircraft wings are designed to stall progressively outward from the wing root
        a. 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
        b. During the recovery, the return of lift begins at the tips and progresses towards the roots
            - Thus, ailerons can be used to level the wings
    ii. If the wing is fully stalled (ailerons included), using the ailerons can result in an aggravated stall condition
        a. 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
            - Increasing the AOA on an already stalled wing will aggravate the stall on that wing
            - The increase in drag and aggravated stall on one wing will yaw the aircraft in the direction of the wing and could result in a spin
D. Rudder and Recovery
    i. Even if excessive aileron was applied, a spin won't occur if yaw is maintained by rudder pressure, therefore it is important that the rudder be used properly during the entry and recovery
    ii. The primary use of rudder is to counteract any tendency of the airplane to yaw or slip
    iii. Maintaining coordinated directional control with the rudder is vital in avoiding a spin
E. Configuration in the Recovery
    i. In a power on stall, the aircraft is often configured for takeoff (takeoff flaps and gear). They also should be practiced clean
        a. Attempting to recover from a stall with the incorrect configuration will result in a less efficient recovery (i.e., a greater loss of altitude) and potentially a crash
        b. Usually the recovery is made by lowering the nose, increasing power, and reestablishing a climb airspeed and attitude. The configuration usually isn't changed since the flaps are already at takeoff
            - Increasing or decreasing the flap setting during this recovery could result in additional loss of altitude
                a More flaps can lead to additional drag and a difficult time establishing a climb and gaining airspeed
                b Less flaps can lead to a significant decrease in lift causing the aircraft to sink
        c. Use the procedures and configurations recommended by the POH

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Factors and Situations that Could Lead to Inadvertent Power-On Stall, Spin, and Loss of Control**
    A. See Part 3, above
2. **Range and Limitations of Stall Warning Indicators**
    A. Stall Warning Horn

        i. The stall warning horn usually comes on 4-8 knots prior to the stall onset to provide warning and time for recovery
            a. Reference the POH for more specifics on the stall warning horn installed on your aircraft in regards to its range and limitations
    B. Buffet
        i. In the case the aircraft is not recovered after the stall warning horn, buffeting or vibrations may begin just prior to the stall
    C. Understanding the signs of an impending stall is extremely important
        i. Not being familiar with these indications can result in a dangerous situation, especially if your stall warning indicator has limitations you are unaware of

3. Failure to Recognize the Stall Warning During Normal Operations
    A. Deeper Stall
        i. The longer it takes the pilot to recognize and recover from the stall, the deeper the stall can become resulting in a greater loss of altitude and a more difficult time recovering the aircraft
    B. Recover from a stall at the first indication of the stall, whether that's a feeling of sinking or mushy controls, the stall warning horn, or aircraft buffet. The sooner the pilot recovers, the safer the situation

4. Improper Stall Recovery Technique
    A. Failure to reduce the AOA
        i. Without reducing the AOA, the aircraft will remain in a stall and altitude will continue to decrease
            a. Since the basic cause of a stall is always an excessive angle of attack (AOA) the cause must be eliminated
    B. Failure to use max power
        i. During takeoff or a go-around, the power may already be at max. If the power is not at max, aircraft performance will be decreased
            a. The climb rate will be reduced
            b. The amount of propeller airflow over the wings is reduced (reducing lift and the aircraft's ability to recover from the stall)
            c. The primary consequence of not max performing is an increased loss of altitude, or a secondary stall
                - The stall can be broken by decreasing the AOA, but without sufficient power the aircraft will not be able to climb or will climb at a reduced rate
                - In the case a climb is attempted without sufficient power, the pilot can quickly put the aircraft into a secondary stall
        ii. Power is essential to regaining airspeed (without losing altitude) and establishing a climb or at least level flight
    C. Failure to use coordinated aileron and rudder to return to straight flight
        i. Stall + Uncoordinated Yaw = Spin. Worst case, an uncoordinated recovery can induce a stall
            a. Maintain coordinated flight during all stall recoveries to prevent spinning the aircraft
        ii. Best case, straight and level flight is regained but at the cost of additional drag due to the uncoordinated flight
            a. This leads to decreased performance, likely resulting in additional altitude lost
    D. Full Stall
        i. Improper recovery procedures can aggravate the stall and lead to a more stalled condition, creating a more difficult situation to recover from
            a. Follow the same steps – relax the back pressure enough to break the stall, add full power, and reestablish straight and level flight with coordinated inputs

5. Secondary Stalls, Accelerated Stall, Elevator Trim Stalls, and Cross-Control Stalls
    A. Secondary Stall

i. A secondary stall occurs after recovery from a preceding stall
    a. It is often caused:
        - By attempting to hasten the completion of a stall recovery before the aircraft has regained sufficient flying speed
        - By the pilot using abrupt control input to return to straight and level flight
        - When the pilot fails to reduce the AOA sufficiently during stall recovering
        - When the pilot attempts to break the stall using power only

ii. Recovery
    a. Release back elevator pressure just like in a normal stall recovery
    b. Increase the power to max
    c. When sufficient airspeed has been regained, the airplane then can be returned to straight and level flight

B. Accelerated Stall

i. The airplane will stall at a higher indicated airspeed when excessive maneuvering loads are imposed on it

ii. Possible Situations
    a. Steep turns, stall and spin recoveries, steep pull ups, or other abrupt changes in the aircraft's flightpath
    b. The AOA may exceed the critical angle while recovering from a steep descent too sharply
        - The relative wind may be aligned with the descent angle causing an almost level pitch attitude stall
    c. The aircraft will stall during a coordinated steep turn exactly as it does from straight and level flight, except the pitching and rolling actions tend to be more sudden
        - Slipping - Tends to roll rapidly toward the outside of the turn (Outside wing stalls 1st)
        - Skidding - Tends to roll rapidly toward the inside of the turn (Inside wing stalls 1st)
        - Coordinated - Both wings stall simultaneously, just like straight and level

iii. Accelerated Stalls tend to be more rapid/severe as they occur at higher airspeeds and lower than normal pitch attitudes

iv. Hazards of Accelerated Stalls
    a. Significant load factor increases can be imposed when pulling out of steep dives or in steep turns
        - This can result in structural damage due to the excessive loads on the airplane (Stay below V_A)

v. Recognizing the Stall
    a. High sink rate, nose-down pitching, extremely negative load factor, loss of control effectiveness
    b. Buffet, stall warning horn will indicate an impending stall
        - The normal nose high attitude and reduction in noise as the aircraft slows does not occur in accelerated stalls

vi. Recovery
    a. The elevator pressure should be released and power increased to break the stall (normal recovery)
    b. If uncoordinated, one wing may drop suddenly
        - Recover by releasing excessive back pressure, adding power, and using coordinated control pressures

C. Elevator Trim Stall

i. The elevator trim stall results from applying full power with the aircraft trimmed for approach or best glide speed

a. The idea is that a go-around is initiated with nose up trim and positive control of the aircraft is not maintained
    - Once at approach speed, the aircraft is trimmed to maintain that speed as it normally would be. If max power is added with no pitch inputs, the aircraft will pitch up excessively
        - a The trimmed condition is perfect for the slow approach speed and lower power setting, but a high-power setting results in an excessive pitch up and can quickly lead to a stall

ii. Recognizing the Stall
   a. When max power is established, the nose will rise quickly to an abnormally high pitch attitude
   b. The signs of a stall may come quickly depending on the speed at which power was added
      - Stall warning horn, buffet, and mushiness

iii. Recovery
   a. Prevent the nose high attitude from occurring in the first place
      - Anticipate the change in pitch attitude and add forward pressure to prevent the nose from rising above a normal climb attitude then retrim the aircraft for a climb
   b. Otherwise, apply the power-on stall recovery procedures

D. Cross-Control Stall
   i. This type of stall occurs with the controls crossed – aileron pressure applied in one direction and rudder pressure in the opposite direction. When excessive back pressure is applied, a cross-control stall may result
   ii. Common Situations
      a. A poorly planned and executed base-to-final approach turn, and often is the result of overshooting the centerline of the runway during that turn
         - Normally, the proper action to correct for overshooting the runway is to increase the rate of turn with coordinated rudder and aileron, but a pilot may limit his or her bank in the pattern during an overshoot and attempt to increase the rate of turn by adding more rudder pressure than required
         - The addition of inside rudder pressure causes the speed of the outer wing to increase, creating greater lift on that wing, and will also lower the nose
            - a To keep the wing from rising, and maintain a constant bank angle, opposite aileron is required
            - b To adjust for the lowered nose, increased back pressure is necessary
            - c The resulting condition is a turn with rudder in one direction, aileron in the opposite direction and excessive back elevator pressure
         - The wing on the outside of the turn speeds up and produces more lift than the inside wing; thus, the aircraft increases bank. The down aileron on the inside of the turn helps drag that wing back, slowing it up and decreasing its lift, which requires more aileron application. This further causes the aircraft to roll.
            - a The roll may be so fast that it is possible the bank will be vertical or past vertical before it is stopped.
      b. Recognizing the Stall
         - Be aware of the cross-controlled situation
            - a Do not use excessive rudder to increase the rate of turn
      c. Recovery from the Stall
         - Recovery must be made before the aircraft enters an abnormal attitude (vertical spiral or spin)
         - It is a simple matter to return to straight-and-level flight by coordinated use of the controls

- The pilot must be able to recognize when this stall is imminent and must take immediate action to prevent a completely stalled condition. It is imperative this type of stall not occur during an actual approach to a landing, since recovery may not be possible prior to ground contact due to the low altitude

6. Effect of Environmental Elements on Aircraft Performance

A. Turbulence
   i. When flying more slowly than minimum drag speed (LD/MAX) the aircraft will exhibit a characteristic know as speed instability
      a. If the aircraft is disturbed by even the slightest turbulence, the airspeed will decrease. As airspeed decreases, the total drag also increases resulting in further loss in airspeed. The total drag continues to rise and speed continues to fall
         - Unless more power is applied and/or the nose is lowered, the speed will continue to decay right down to the stall
   ii. The pilot must understand that, at speed less than minimum drag speed, the airspeed is unstable and will continue to decay if allowed to do so

B. Microbursts
   i. A strong downdraft which normally occurs over horizontal distances of 1 NM or less and vertical distances of less than 1,000'. In spite of its small horizontal scale, an intense microburst could induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm.
   ii. In a situation such as takeoff or the departure climb, when the aircraft is in a high angle of attack, and slow airspeed, there is minimal ability for the aircraft to climb, especially in the case of a microburst
      a. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common. In the case of a microburst, recover from slow flight and establish the best climb configuration and climb airspeed for your aircraft
   iii. The FAA has developed a Pilot Windshear Guide Advisory Circular (AC 00-54)
      a. Included is information on how to recognize the risk of a microburst encounter, how to avoid an encounter and the best flight strategy for successful escape should an encounter occur

C. Density Altitude
   i. Pressure Altitude
      a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
         - $1{,}000(29.92 - \mathrm{Alt}) + \mathrm{Elev}$
      b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
         - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.
         - High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather
   ii. Density Altitude/Temperature
      a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
         - $120(°\mathrm{C} - 15°\mathrm{C}) + \mathrm{PA}$ (this is an approximation)
      b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
         - Lower temperatures (the air is more compressed) result in better performance
         - Higher temperatures (the air is less compressed) result in poorer performance

- Although a low-pressure system may come through, very cold weather has an opposite effect on performance
    - a Lower temperatures result in better performance
    - b Overall, high pressure, cold days result in the best performance

iii. Humidity
   a. Although not directly accounted for on the performance charts, humidity decreases performance

iv. In relation to power-on stalls, the aircraft will perform better in lower pressure and density altitudes as well as with lower amounts of humidity and will perform worse in the opposite conditions
   a. Therefore, the aircraft will have a more difficult time maintaining airspeed and altitude in poorer atmospheric conditions

7. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Minimum Altitudes for the Power-On Stall Maneuver

i. Single Engine Aircraft
   a. Complete the maneuver no lower than 1,500' AGL. This is because an average spin rotation in a single engine aircraft takes approximately 500' of altitude. This minimum altitude allows for recovery from a spin within two turns + 500' (3 full rotations before reaching the ground)

ii. Multi Engine Aircraft
   a. Complete the maneuver no lower than 3,000' AGL. This is because an average spin rotation in a multi engine aircraft takes approximately 1,000' of altitude. This minimum altitude allows for recovery from a spin within two turns + 1,000' (3 full rotations before reaching the ground)

B. Collision Avoidance

i. Operation Lights On
   a. A voluntary FAA safety program to enhance the see and avoid concept
   b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
      - If they are different categories:
         - a A balloon has the right of way over any other category
         - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
         - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
         - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
   c. Approaching Head-on
      - Each pilot shall alter course to the right
   d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
   e. Landing

- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
    - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
    - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary
   c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

C. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

D. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

        a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
        b. Become familiar with any obstacles on the approach and departure path
        c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
        d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
        e. NOTAMs are issued on lighted structures experiencing light outages
    ii. Antenna Towers
        a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
            - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing
    iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
        a. Ensure proper clearance between the aircraft and obstacle
            - If unsure of clearance, stop until you're sure it is safe to pass
    v. If necessary, radio ground to inform them of your intentions or ask for assistance

8. **Distractions, Loss of Situational Awareness, and/or Improper Task Management**
    A. Distractions
        i. During power-on stalls, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
            a. Flying takes precedence
                - Aviate, Navigate, Communicate
                - In the case of a real-life power-on stall recovery, it is essential the pilot safely recover the aircraft
        ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
        iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
            a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing
    B. Situational awareness is extremely important when operating in the pattern and in configurations associated with power-on stalls. A loss of situational awareness can lead to a power-on stall, mishaps, or incursions on the ground or in the air
        i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
        ii. Maintain situational awareness
            a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem
    C. Task Management
        i. Attention needs to be divided between the various required tasks

a. No one responsibility should take your full attention full more than a short period
    - Continually move between tasks to ensure everything is being taken care of
    - By effectively dividing attention, the pilot can deter the chance of a power-on stall

b. Safety is your number one priority
    - Aviate, Navigate, Communicate

ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.

a. Checklists are extremely helpful in properly managing tasks

iii. Recognize when you are getting behind the aircraft, 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

c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Select an entry altitude that will allow the Task to be completed no lower than 1,500 feet AGL (ASEL) or 3,000 feet AGL (AMEL).
3. Establish the takeoff, departure, or cruise configuration, as specified by the evaluator, and maintain coordinated flight throughout the maneuver.
4. Set power (as assigned by the evaluator) to no less than 65 percent available power.
5. Transition smoothly from the takeoff, departure, or cruise attitude to the pitch attitude that will induce a stall.
6. Maintain a specified heading, ±10° if in straight flight; maintain a specified angle of bank not to exceed 20°, ±10°, if in turning flight, while inducing the stall.
7. Acknowledge the cues of the impending stall and then recover promptly after a full stall occurs.
8. Execute a stall recovery in accordance with procedures set forth in the POH/AFM.
9. Configure the aircraft as recommended by the manufacturer and accelerate to V_X or V_Y.
10. Return to the altitude, heading, and airspeed specified by the evaluator.

VII.D. Spin Awareness

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Stall and Spin Awareness Training (AC 61-67), POH/AFM

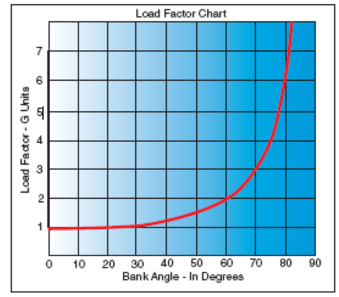
KNOWLEDGE

The applicant demonstrates understanding of:

1. **Aerodynamics Associated with Spins in Various Aircraft Configurations, to include the Relationship Between:**
   - A. Angle of Attack (AOA)
     - i. Defined: The acute angle between the chord line of the airfoil and the direction of the relative wind
       - a. As the airspeed slows, the angle between the chord line and the relative wind increases (assuming everything else remains the same)
         - For example, imagine straight and level flight at 100 knots. As the aircraft slows to 60 knots, in order to maintain straight and level flight, the nose must be raised (the lift lost due to the decreasing airspeed is replaced by increasing the angle of attack). Therefore, the relative wind remains the same (the aircraft is still straight and level), but the angle of attack is considerably higher than at 100 knots.
       - b. Critical Angle of Attack: The angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight
     - ii. AOA and Airspeed
       - a. As mentioned above, decreasing airspeed necessitates an increasing AOA to maintain lift and vice versa (increasing airspeed, requires a decreasing angle of attack to maintain the same amount of lift)
       - b. When the aircraft slows enough and reaches the critical angle of attack the aircraft will stall
     - iii. AOA and Load Factors
       - a. As the load factor ("weight") increases, the AOA must be increased to compensate for the additional weight and the opposite applies (less load factor = less AOA)
       - b. Increased load factor results in an increased AOA which can lead to exceeding the critical angle of attack and a stall
     - iv. AOA and Configuration
       - a. When the flaps are lowered, the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
         - For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
         - The aircraft now has a lower AOA than with the flaps retracted, the lower AOA means there is a greater distance between the aircraft's AOA and the critical AOA and therefore the aircraft will stall at a slower airspeed
     - v. AOA and Weight
       - a. Increased weight results in an increased AOA to maintain altitude. The heavier the plane the more lift required and vice versa
       - b. The heavier the aircraft, the closer the AOA is to the critical angle of attack and easier it is to stall
     - vi. AOA and Attitude
       - a. Changing the AOA usually is a direct change in the aircraft attitude, specifically the pitch of the aircraft

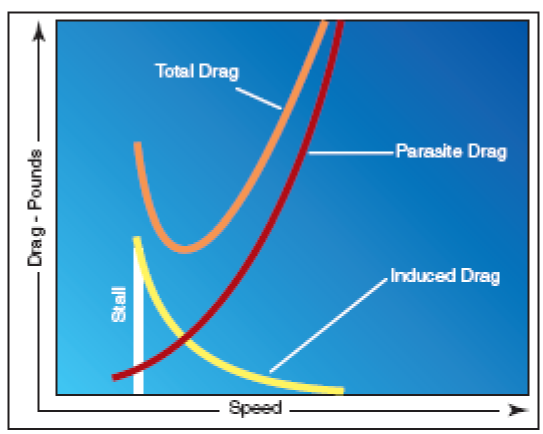
B. Airspeed
   i. An increase or decrease in airspeed increases or decreases lift and thus can have an effect on AOA and the attitude of the aircraft
      a. AOA would have to increase with a loss of airspeed and vice versa

C. Load Factor
   i. Load factor is the ratio of the total load acting on the airplane to the gross weight of the airplane
      a. Expressed in terms of G's



   ii. Turns
      a. Increased load factors are a characteristic of all banked turns
      b. Load factor increases at a high rate after 45°-50° of bank
   iii. An increased load factor effectively increases the weight of the aircraft during the time that the load factor is imposed
      a. For example, in cruise flight an aircraft may be at 1 G and weigh 2,000 lbs. In a 60-degree banked turn holding altitude the aircraft is at 2 G's and effectively has increased its weight to 4,000 lbs. while at 2 G's
      b. The increased load factor requires a higher AOA or airspeed or both to compensate for the additional load during the maneuver
   iv. An increase or decrease in the load factor effectively increases or decreases the weight of the aircraft and thus can affect the AOA, airspeed, weight, and attitude of the aircraft
      a. An increased load factor effectively makes the aircraft seem heavier to the flight controls and therefore, to maintain altitude the AOA would have to be increased to generate the additional lift required
      b. An increased load factor could also be compensated for by increasing the airspeed
         - This would generate additional lift to compensate for the "increased weight" and thus allow the AOA to stay the same
   v. In relation to spins, the higher the load factor, the higher the stall speed due to the higher AOA required

D. Power Setting
   i. It is important to know the relationship between parasite drag, induced drag, and the power needed to maintain a given altitude at a selected airspeed
      a. As airspeed decreases from cruise to L/D_{MAX}, total drag and thrust required decrease to maintain a constant altitude
      b. As airspeed decreases below L/D_{MAX}, additional power (thrust) is required to maintain a constant altitude
         - Total drag is now increasing because induced drag increases faster (due to higher the angle of attack) than parasite drag decreases
         - This is known as the 'backside of the power curve' or the 'region of reverse command'
            a The Region of Reverse Command means that more power is required to fly at slower airspeeds while maintaining a constant altitude



   ii. While straight and level flight is maintained at a constant airspeed, thrust is equal in magnitude to drag, and lift is equal to weight, but some of these forces are separated into components

a. In slow flight (which can often lead to a power-off stall), thrust no longer acts parallel to and opposite to the flight path and drag.
    - In slow flight, thrust has two components:
        a One acting perpendicular to the flight path in the direction of lift
        b One acting along the flight path
b. Because the actual thrust is inclined, its magnitude must be greater than drag if its component acting along the flight path is equal to drag
    - The forces acting upward (wing lift and the component of thrust) equal the forces acting downward (weight and tail down force)
c. Wing loading is actually less during slow flight because the vertical component of thrust helps support the airplane

iii. The flight controls in slow flight are less effective than at normal cruise due to the reduced airflow over them
   a. As airspeed decreases, control effectiveness decreases disproportionately
      - There is a loss of effectiveness when the airspeed is reduced from 30 to 20 knots above the stall speed, but there is a considerably greater loss as the airspeed is reduced to 10 knots above the stall speed
   b. Anticipate the need for right rudder to counteract the left turning tendencies in a low airspeed, high power setting condition
   c. Large control movements may be required
   d. This does not mean rough or jerky movements

iv. In relation to spins, a high-power setting may allow the aircraft to stall at a lower airspeed, but also creates a greater requirement for yaw that must be kept coordinated with right rudder

E. Aircraft Weight
   i. An increase in weight is similar to an increase in load factor, except that the increased weight exists throughout the entire flight, rather than during the specific maneuver that will change the aircraft's load factor (G's)
      a. Increasing weight requires an increased AOA or airspeed to compensate for the additional lift required
   ii. Increased weight can lead to a stall at higher airspeeds due to the higher AOA required

F. Center of Gravity
   i. An airplane with forward loading
      a. The aircraft acts heavier, and consequently slower than the same airplane with a further aft CG
         - Nose up trim is required which requires the tail surfaces to produce a greater download which adds to the wing loading and the total lift required to maintain altitude
      b. Requires a higher angle of attack, resulting in more drag and a higher stall speed
      c. The aircraft is more controllable though
         - This is due to the longer arm from the elevator to the CG
   ii. With aft loading (aircraft acts lighter), the airplane requires less download allowing for a faster cruise speed
      a. Faster cruise because of reduced drag
         - Reduced drag is a result of a smaller angle of attack and less downward deflection of the stabilizer
      b. The tail surface is producing less down load, relieving the wing of loading and lift required to maintain altitude
         - Results in a lower stall speed
      c. Recovery from a stall becomes progressively more difficult as the CG moves aft

- Moving the CG aft shortens the arm from the elevator, reducing the amount of force it can apply

iii. A forward loaded aircraft is closer to the critical angle of attack but also has more control due to the long moment arm from the elevator to the forward CG

iv. An aft loaded aircraft flies at a lower pitch attitude and therefore farther away from the critical AOA, but will have less control in the case of a stall/spin

G. Aircraft Attitude

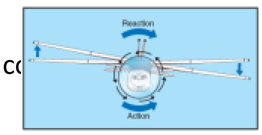
i. A change in attitude is simply a change in the aircraft's position in space. Everything else remaining the same, all of the factors will have some effect on the aircraft's attitude and most likely will result in an increase or decrease in pitch

H. Yaw Effects

i. Torque (the left turning tendency of the aircraft) is made up of 4 elements which produce a twisting axis around at least 1 of the aircraft's 3 axes

a. Torque Reaction, Corkscrew Effect of the Slipstream, Gyroscopic Action of the Prop, and P-Factor

ii. Torque Reaction



a. Although torque reaction is more of a rolling tendency than a yaw effect, it does c
the left turning tendencies of the aircraft

b. Newton's 3rd Law – For every action there is an equal and opposite reaction

- The engine parts/propeller rotate one way; an equal force attempts to rotate the plane the opposite direction

c. When airborne, this force acts around the longitudinal axis, resulting in a left rolling tendency

d. On the ground, during takeoff, the left side is being forced down resulting in more ground friction

- This causes a turning moment to the left that is corrected with rudder
  - a Strength is dependent on engine size/hp, propeller size/rpm, plane size and ground surface
    1. The higher the power setting, the greater the left turning tendency

iii. Torque is corrected by offsetting the engine, and using aileron trim tabs, and aileron/rudder use

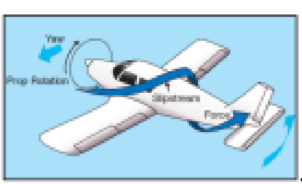
- Most aircraft engines are not installed on the centerline of the aircraft (on the longitudinal axis), they are offset in order to counteract a portion of the rolling motion caused by torque
- Trim tabs can be adjusted to counter the turning tendency in level flight
- Torque that is not countered by the engine and trim tab position must be corrected with coordinate rudder and aileron inputs

iv. Corkscrew/Slipstream Effect

a. The high-speed rotation of the propeller sends the air in a corkscrew/spiraling rotation to the rear of the aircraft

- The 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 very compact



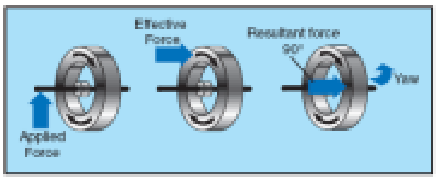
- This exerts a strong sideward force on the vertical tail causing a left turn around the vertical axis
- The corkscrew flow also creates a rolling moment around the longitudinal axis
  - a The rolling moment is to the right and may counteract torque to an extent

. As the forward speed increases, the spiral elongates and becomes less effective

d. The slipstream effect is countered with coordinate rudder and aileron and is most pronounced in climbs (high prop speed and low forward speed)

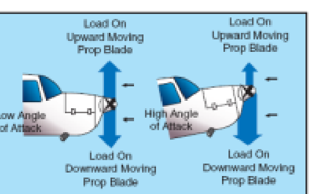
e. In relation to slow flight, such as during a takeoff climb, the high propeller speed and low forward speed results in a relatively pronounced slipstream effect which should be countered with right rudder, and aileron as necessary

v. 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
            2. Ex: This most often occurs with tail wheel aircraft when the tail is being 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
                  i. This force is felt 90° in the direction of rotation (clockwise as viewed from the cockpit)
               b. The forward force will take effect on the Right side of the propeller, yawing the aircraft Left
   b. In relation to slow flight, lifting the nose would result in a left yawing motion on the aircraft
      - Any yawing around the vertical axis results in a pitching moment
      - Any pitching around the lateral axis results in a yawing moment
      - Correction is made with necessary elevator and rudder pressures

vi. Asymmetric Loading (P Factor)
   a. When flying with a high AOA, the bite of the down moving blade is greater than the up moving blade
      - This moves the center of thrust to the right of the propeller disc area (causing a yaw to the left)
   b. This is caused by the resultant velocity, which is generated by the combination of the prop blade velocity in its rotation and the velocity of the air passing horizontally through the prop disc



      - At positive AOA, the right blade is passing through an area of resultant velocity greater than the left
      - Since the prop is an airfoil, increased velocity means increased lift
         a Therefore, the down blade has more lift and tends to yaw the plane to the left
   c. EXAMPLE: Visualize the prop shaft mounted perpendicular to the ground (like a helicopter)
      - If there were no air movement at all, except that generated by the prop, identical sections of the blade would have the same airspeed
      - 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
         a The blade proceeding is creating more lift or thrust, moving the center of lift toward it
      - Visualize rotating the prop to shallower angles relative to the moving air (as on an airplane)
         a The unbalanced thrust gets smaller until it reaches zero when horizontal to the airflow
   d. Summary: The descending blade of the propeller 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 the aircraft will have a tendency to yaw to the left
   e. 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

vii. Yaw Effects and Spins

a. During the high-power settings and high AOA, considerable right rudder is required to maintain coordinated flight
    - The amount of rudder necessary can be learned through experience, but it most cases it is similar to the rudder required during takeoff

b. In order to avoid a spin, it is imperative that the pilot keep the aircraft coordinated

I. Configuration

i. In the case of configuration changes, we'll look simply at flaps and the gear

a. Flaps
    - When the flaps are lowered the AOA increases because the chord line moves to a steeper angle, therefore more lift is generated at the same pitch attitude
        - a For this reason, the nose of the aircraft has to be lowered to maintain altitude when the flaps are lowered and airspeed remains the same
    - Flaps also result in additional drag due to the increased lift and additional surface area protruding into the wind
    - Adding flaps can change the AOA, airspeed, and attitude of the aircraft
        - a As mentioned above, the AOA changes since flaps are designed to influence the AOA
        - b The airspeed will decrease due to the additional drag, and therefore power will have to be increased to maintain the same speed
        - c Attitude will change due to the changing configuration, and AOA
    - The flaps will reduce the stall airspeed, providing more cushion to avoid a spin

b. Gear
    - In the case you have retractable gear, lowering the gear will result in additional drag and in some cases, it may affect the pitch of the aircraft and therefore make a small change to the AOA
    - As gear is lowered, additional power is required to maintain airspeed and in the case that the gear does have an effect on the AOA, the pitch/attitude will have to be adjusted to compensate

2. What Causes a Spin and How to Identify the Entry, Incipient, and Developed Phases of a Spin

A. What Causes a Spin

i. Requirements for a Spin

a. Both wings must first be stalled; then one wing becomes less stalled than the other
    - The airplane must be in a stall
    - The airplane must be in uncoordinated flight

ii. Basically,

a. The autorotation results from an unequal angle of attack on the airplane's wings
    - The lowered wing has an increasing AOA, past the critical AOA - lift decreases and drag increases
    - The rising wing has a decreasing AOA, allowing lift to increase and drag to decrease
        - a The rising wing is less stalled

iii. Specifically,

a. Often one wing will drop at the beginning of a stall causing the nose to yaw to the low wing
    - This is where rudder is important during a stall - Maintaining directional control to avert a spin

b. If the airplane is allowed to yaw, one wing will drop in the direction of the yaw (the other will rise)

c. Lowered Wing
    - Unless rudder is used to correct the yaw, the airplane will begin to slip to the lowered wing

            a Results in a weathervane into the relative wind (to the low wing), increasing the yaw
            b The airplane also continues to roll toward the lowered wing
    d. The lowered wing has an increasingly greater AOA due to the upward motion of the relative wind
        - It is then well beyond the critical AOA and suffers an extreme loss of lift and increase in drag
    e. Raised Wing
        - The rising wing has a smaller/decreasing AOA since the relative wind is striking at a smaller angle
            a The rising wing is less stalled and develops some lift causing the airplane to continue rolling
                1. Creating the yawing and pitching motion

B. Phases of a Spin
    i. Entry Phase
        a. This phase is where the pilot provides the necessary elements for the spin (whether accidental or intentional)
            - How to Identify the Phase: As the aircraft approaches a stall, rudder is applied in the direction of what will be the spin rotation
                a Stall + Uncoordinated Yaw
    ii. Incipient Phase
        a. This phase is from the time the aircraft stalls and rotation starts until the spin has fully developed
            - This change may take up to two turns for most aircraft
            - In this phase, the aerodynamic and inertial forces have not achieved balance
        b. How to Identify the Phase: As the incipient spin develops, the indicated airspeed should be near or below stall airspeed, and the turn-and slip indicator should indicate the direction of spin
    iii. Developed Phase
        a. This phase occurs when the aircraft's angular rotation rate, airspeed, and vertical speed are stabilized while in a flightpath that is nearly vertical. The aircraft aerodynamic forces and inertial forces are in balance, and the attitude, angles and self-sustaining motions about the vertical axis are constant or repetitive
        b. How to Identify the Phase: Airspeed, vertical speed, and rate of radiation are stabilized while in a flightpath that is nearly vertical

3. Spin Recovery Procedure

A. Step 1 – POWER IDLE
    i. Power aggravates the spin characteristics, resulting in a flatter spin and increased rotation

B. Step 2 – AILERONS NEUTRAL
    i. Ailerons may have an adverse effect on recovery
        a. Ailerons in the direction of the spin may speed the rotation, delaying recovery
        b. Ailerons opposite the spin may cause the down aileron to force a deeper stall

C. Step 3 – RUDDER OPPOSITE THE ROTATION
    i. FULL (to the stop) rudder opposite the rotation

D. Step 4 - ELEVATOR FORWARD
    i. To break the stall, apply a positive/brisk, straight forward movement of the elevator
        a. Immediately after full rudder application and hold firmly in this position
        b. This will decrease the AOA and break the stall (spinning will stop when broken)

E. Step 5 – RUDDER NEUTRAL
    i. If not neutral the increased airspeed will cause a yawing or skidding effect

    ii. Also, if the stall is not broken or is reentered and full rudder is held, a spin can quickly start in the opposite direction
  F. Step 6 – ELEVATOR BACK PRESSURE
    i. Once broken, raise the nose to level flight - Be careful of a secondary stall and exceeding load limits
  G. Avoid excessive speed or an accelerated stall during recovery
    i. Once the spin is stopped and the stall broken, smoothly raise the nose to maintain level flight
      a. Avoid aggressive movements resulting in an accelerated stall or a secondary stall
    ii. Once the spin is stopped and the stall broken, smoothly raise the nose maintain level flight, or establish a climb – do not leave the aircraft in a nose low attitude while altitude decreases and airspeed increases
  H. The engine may stop producing power due to centrifugal force acting on the fuel tanks - Assume power will not be available
    i. In the case power is unavailable pitch for best glide speed and make an emergency landing at the nearest suitable landing area
  I. The recovery occurs when the AOA of the wings decrease below the critical AOA and autorotation slows
    i. Then, the nose steepens and rotation stops – may last ¼ of a turn to several turns
      a. This is the point at which the rudder should be neutralized and elevator back pressure smoothly applied to regain straight and level flight

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Factors and Situations that Could Lead to Inadvertent Spin and Loss of Control
  A. See Power-Off Stalls, Part 3.
    i. All situations that could lead to a power-off stall could also lead to a spin if the stall is not recovered promptly/correctly and yaw is introduced
  B. See Power-On Stalls, Part 3.
    i. All situations that could lead to a power-on stall could also lead to a spin if the stall is not recovered promptly/correctly and yaw is introduced

2. Range and Limitations of Stall Warning Indicators
  A. Stall Warning Horn
    i. The stall warning horn usually comes on 4-8 knots prior to the stall onset to provide warning and time for recovery
      a. Reference the POH for more specifics on the stall warning horn installed on your aircraft in regards to its range and limitations
  B. Buffet
    i. In the case the aircraft is not recovered after the stall warning horn, buffeting or vibrations may begin just prior to the stall
  C. Understanding the signs of an impending stall is extremely important
    i. Not being familiar with these indications can result in a dangerous situation, especially if your stall warning indicator has limitations you are unaware of

3. Improper Spin Recovery Procedures
  A. Improper flight controls during recovery can aggravate the stall, or prevent recovery
    i. Step 1 - Power Idle
      a. Leaving the power above idle aggravates the spin

ii. Step 2 - Ailerons Neutral
    a. Aileron inputs can further aggravate the stall by increasing the AOA on an already stalled wing
iii. Step 3 - Rudder Opposite
    a. This is necessary to stop the spin. Not using sufficient rudder will not break the spin, and using opposite rudder will aggravate the spin
iv. Step 4 - Elevator Down
    a. This is necessary to break the stall. Without the elevator input, the stall won't be broken and the spin will continue
v. Step 5 - Rudder Neutral
    a. If the aircraft is spinning left and right rudder is input, as directed in step 3, but held in (no returned to neutral) the aircraft will begin a spin to the right
vi. Elevator Back Pressure
    a. Stopping the descent and establishing straight and level flight is necessary to return to level flight/establish a climb and for survival. Gently increase back pressure; avoid a secondary stall

4. Effect of Environmental Elements on Aircraft Performance

A. Turbulence
  i. When flying more slowly than minimum drag speed (LD/MAX) the aircraft will exhibit a characteristic know as speed instability
    a. If the aircraft is disturbed by even the slightest turbulence, the airspeed will decrease. As airspeed decreases, the total drag also increases resulting in further loss in airspeed. The total drag continues to rise and speed continues to fall
      - Unless more power is applied and/or the nose is lowered, the speed will continue to decay right down to the stall
  ii. The pilot must understand that, at speed less than minimum drag speed, the airspeed is unstable and will continue to decay if allowed to do so

B. Microbursts
  i. A strong downdraft which normally occurs over horizontal distances of 1 NM or less and vertical distances of less than 1,000'. In spite of its small horizontal scale, an intense microburst could induce windspeeds greater than 100 knots and downdrafts as strong as 6,000 fpm.
  ii. In a situation such as takeoff or the departure climb, when the aircraft is in a high angle of attack, and slow airspeed, there is minimal ability for the aircraft to climb, especially in the case of a microburst
    a. A stall and spin during a microburst might be one of the worst possible situations imaginable for an aircraft
    b. Do not fly in or around thunderstorms or heavy rain showers where microbursts are most common. In the case of a microburst, recover from slow flight and establish the best climb configuration and climb airspeed for your aircraft
  iii. The FAA has developed a Pilot Windshear Guide Advisory Circular (AC 00-54)
    a. Included is information on how to recognize the risk of a microburst encounter, how to avoid an encounter and the best flight strategy for successful escape should an encounter occur

C. Density Altitude
  i. Pressure Altitude
    a. Pressure Altitude: Altitude above the standard 29.92" Hg plane
      - $1{,}000(29.92 - \text{Alt}) + \text{Elev}$
    b. As air masses move, they carry different levels of pressure. Those different pressure levels affect engine performance
      - A higher air pressure (more air in a given volume) results in better engine performance (more combustion). Less pressure results in poorer performance.

- High air pressure is often associated with good weather, low air pressure is often associated with storms and poor weather

ii. Density Altitude/Temperature

a. Density Altitude: Pressure altitude corrected for nonstandard temperature. Density altitude is used in computing the performance of aircraft and its engines.
   - $120(°\mathrm{C} - 15°\mathrm{C}) + \mathrm{PA}$ (this is an approximation)

b. Pressure altitude corrects for non-standard pressure, whereas density altitude takes it at step further and corrects pressure altitude for non-standard temperatures
   - Lower temperatures (the air is more compressed) result in better performance
   - Higher temperatures (the air is less compressed) result in poorer performance
   - Although a low-pressure system may come through, very cold weather has an opposite effect on performance
     - a Lower temperatures result in better performance
     - b Overall, high pressure, cold days result in the best performance

iii. Humidity

a. Although not directly accounted for on the performance charts, humidity decreases performance

iv. The aircraft will perform better in lower pressure and density altitudes as well as with lower amounts of humidity and will perform worse in the opposite conditions

a. Therefore, the aircraft will have a more difficult time maintaining airspeed and altitude in poorer atmospheric conditions

5. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Altitude Loss During a Spin

i. Each turn takes approximately 3 seconds and small, single engine training aircraft lose approximately 500’ per turn

B. Collision Avoidance

i. Operation Lights On

a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other’s right has the right-of-way.
   - If they are different categories:
     - a A balloon has the right of way over any other category
     - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
     - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
     - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
   - Each pilot shall alter course to the right

d. Overtaking
    - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
    - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
    - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
    - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
    - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
    - This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

C. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield

a. Study sectionals and terminal area charts

b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
    - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

D. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
      b. Become familiar with any obstacles on the approach and departure path
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing
   iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
      a. Ensure proper clearance between the aircraft and obstacle
         - If unsure of clearance, stop until you're sure it is safe to pass
   v. If necessary, radio ground to inform them of your intentions or ask for assistance

6. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. During spins, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
      a. Flying takes precedence
         - Aviate, Navigate, Communicate
         - In the case of a real-life spin recovery, it is essential the pilot safely recover the aircraft
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin
   iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
      a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing
B. Situational awareness is extremely important in preventing stalls and spins. A loss of situational awareness can lead to a stall, spin, mishap, or incursion on the ground or in the air
   i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   ii. Maintain situational awareness
      a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
   i. Attention needs to be divided between the various required tasks
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
         - By effectively dividing attention, the pilot can deter the chance of a stall and spin
      b. Safety is your number one priority
         - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
      a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, 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
      c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

None (Intentionally left blank in the ACS)

BASIC INSTRUMENT MANEUVERS

VIII.A. Straight-and-Level Flight

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Flight Instruments Sensitivity, Limitations, and Potential Errors in Unusual Attitudes**
    - A. Attitude Indicator
        - i. Spillable Indicators
            - a. Do not depend on the attitude indicator during an unusual attitude if it is the spillable type, because its upset limits may have been exceeded or it may have become inoperative due to mechanical malfunction
        - ii. Nonspillable Indicators
            - a. If operating properly, errors up to 5 degrees of pitch and bank may result and indications are very difficult to interpret in extreme attitudes
    - B. Heading Indicator
        - i. Verify the heading indicator against the magnetic compass
            - a. This can be difficult in an unusual attitude since the compass may be swinging somewhat wildly. Wait for it to settle to ensure the heading indicator is accurate and has not precessed
    - C. Be aware of any limitations, errors, etc. associated with your specific flight instruments
2. **Flight Instrument Correlation (Pitch/Bank Instruments)**
    - A. Pitch Instruments (Constant Altitude/Level Flight)
        - i. The Instruments
            - a. Altimeter
            - b. Attitude Indicator
            - c. Vertical Speed Indicator (VSI)
        - ii. Procedure for Basic Instrument Maneuvers
            - a. Establish
                - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, straight and level flight
                - Pitch Instruments: Set the attitude indicator on the horizon
            - b. Trim
                - Trim the pitch control pressure for hands off flight
            - c. Crosscheck
                - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
                    - a The altimeter should indicate a steady altitude (level flight)
                    - b The VSI should indicate zero (no climb or descent)
                    - c The airspeed should be constant
                        1. Increasing airspeed, can be a sign of a descent (with no other changes in power, configuration, etc.). Decreasing airspeed is a sign of a climb
            - d. Adjust
                - In the case of a climb or descent, make adjustments corresponding to the amount of change
                - 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
    e. Repeat the steps. After making an adjustment, trim the aircraft, crosscheck the instruments, and readjust if necessary…

B. Bank Instruments (Constant Heading/Straight Flight)
    i. The Instruments
        a. Heading Indicator
        b. Attitude Indicator
        c. Turn Coordinator
        d. Magnetic Compass
    ii. Procedure for Basic Instrument Maneuvers
        a. Establish
            - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, straight and level flight
            - Bank Instruments: Set the attitude indicator for wings level flight
        b. Trim
            - Trim the pitch control pressure for hands off flight
            - Rarely do general aviation aircraft have bank trim
        c. Crosscheck
            - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
                a The heading indicator should indicate a steady heading (straight flight)
                b The magnetic compass should also indicate a steady heading (straight flight)
                c The turn coordinator should indicate zero rate of turn and coordinated flight
        d. Adjust
            - If the airplane is banking in one direction or the other, the bank should be readjusted to put the wings level on the attitude indicator
            - 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
            - It's important not to correct heading errors solely by yawing or rolling the airplane
                a Maintain a coordinated flight condition with coordinated aileron and rudder
                b Uncoordinated flight creates drag, slowing the aircraft since the fuselage is put into the relative wind

C. Pitch, Bank, and Power Settings for Straight-and-Level Flight

Pitch + Power = Desired Performance

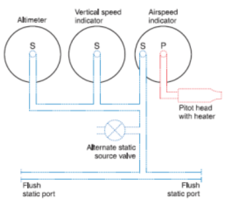
Nose on Horizon + Wings Level + Cruise Power = Straight and Level

Pitch		Bank	
A/I	On Horizon	A/I	Wings Level
Alt	Constant	DG/Hdg Ind	Constant
VSI	0	Compass	Constant
Airspeed	Constant Cruise AS	T/C	Level/Coordinated

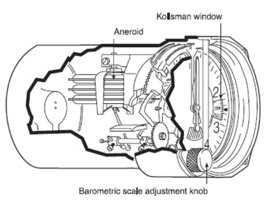
i. Establish **-** Use the attitude indicator to establish a wings level, nose on the horizon attitude, adjusting power as needed
ii. Trim - Trim to relieve the control pressures
iii. Crosscheck – ensure the desired flight performance on the instruments
iv. Adjust - Correct any performance errors as necessary and re-trim the airplane, then crosscheck again

3. Flight Instrument Function and Operation

A. Pitot-Static System (Altimeter, Vertical Speed Indicator, Airspeed Indicator)
   i. How it Works



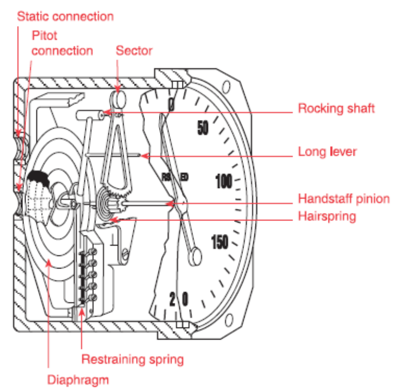
      a. Flight instruments depend on accurate sampling of the ambient atmospheric pressure
         - This is used to determine the height and speed of movement of the aircraft through the air
      b. Static Pressure (still air pressure) is measured at a flush port where air is not disturbed
         - Pressure 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
   ii. 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’
            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, lowering true altitude and putting the aircraft in a potentially dangerous position (lower than the altimeter indicates)
            b The opposite applies from Low pressure to High pressure
         - REMEMBER: From hot to cold, or from high to low, look out below!

iii. 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 instrument 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

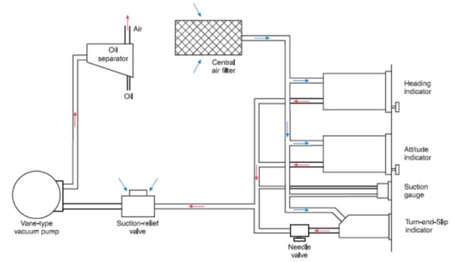
iv. Airspeed Indicator
   a. A differential pressure gauge measuring the dynamic pressure of the air the aircraft is in
      - Dynamic Pressure: the difference in ambient static air pressure and the total, or ram, pressure caused by the motion of the aircraft through the air (the difference between pitot and static pressure)



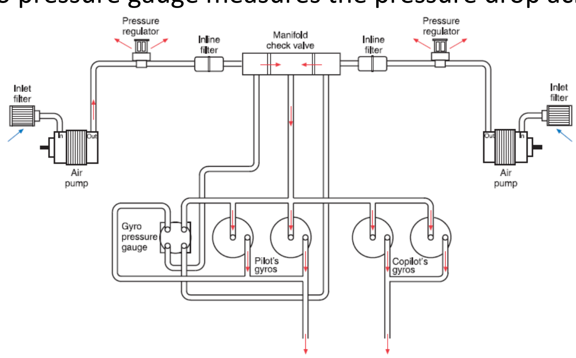
   b. Principle of Operation
      - Consists of a thin, corrugated phosphor bronze aneroid, or diaphragm, receiving its pressure from the pitot tube
      - The instrument is sealed and connected to the static port(s)
      - As pitot pressure increases or static decreases, the diaphragm expands and vice versa
         a A rocking shaft and set of gears drives the AS needle

B. Gyroscopic System (Attitude & Heading Indicators, 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 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
            c Some attitude indicators can tumble (lose their rigidity) if the aircraft pitch/bank attitude reaches a certain point. Beyond this point the attitude indicator may be unreliable

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
        - Precession can cause errors over time

iv. Turn Indicators
    a. Rate instruments operate on the principle of precession
    b. Turn-and-Slip Indicator
        - A small gyro mounted in a single gimbal
            a Gyro spin axis is parallel to the lateral axis; the gimbal axis is parallel to the longitudinal
        - Yawing, or rotating about the vertical axis, produces a force in the horizontal plane
            a This, due to precession, causes the gyro and its gimbal to rotate about the gimbal axis
        - Inclinometer
            a A black glass ball sealed inside a curved glass tube that is partially filled with a liquid
            b When straight and level, there is no inertia acting on the ball and it remains centered
            c In a turn with too steep a bank angle, gravity exceeds inertia and the ball rolls inward
            d In a turn with too shallow of bank, inertia exceeds gravity and the ball rolls outward
            e Only indicates the relationship between the angle of bank and the rate of yaw
    c. Turn Coordinator
        - Similar to the Turn and Slip Indicator, but its gimbal frame is angled upward about 30° from the longitudinal axis of the airplane
            a This allows it to sense both roll and yaw (not just yaw like the T&S Indicator)
        - The inclinometer is the same, and called a coordination ball
            a Shows the relationship between the bank angle and rate of yaw
                1. Skidding when the ball rolls outside the turn
                2. Slipping when the ball rolls inside the turn

C. Magnetic Compass

i. Operation
    a. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid
    b. A card is wrapped around the float and visible from the outside with a lubber line
        - Lubber Line: The reference line used in a magnetic compass or heading indicator
    c. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup
        - The buoyancy of the float takes most of the weight off the pivot
        - The jewel and pivot type mounting allows the float to rotate and tilt up to approximately 18°

d. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line
    - The pilot sees the card from its backside
        - a The reason for this is the card remains stationary and the housing/pilot turn around it

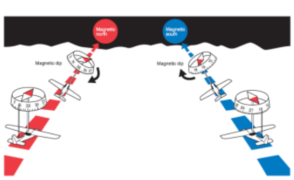
ii. Errors

a. Variation
    - Caused by the difference in the locations of the magnetic and geographic north pole
    - The north magnetic pole is not collocated with the geographic north pole
        - a The difference between true and magnetic directions
    - Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
    - Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation

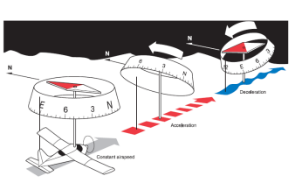
b. Deviation
    - Caused by local magnetic fields within the aircraft; different on each heading
    - The magnets in a compass align with any magnetic field
        - a Local magnets caused by electrical currents will conflict with the Earth's field
    - Deviation varies by heading and is shown on a compass correction card

c. Finding the Compass Course
    - True Course ± Variation = Magnetic Course ± Deviation = Compass Course
    - Remember: East is Least, West is Best
        - a Subtract variation from true course, Add variation to true course

d. Dip Errors
    - What's Going On
        - a The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
            1. At both poles, the lines are perpendicular to the surface
            2. Over the equator, the lines are parallel to the surface
        - b The magnets align with these fields and near the poles they dip, tilt, the float/card
        - c The float is balanced with a small dip compensating weight, so it stays relatively level
    - Northerly Turning Error
        - a Caused by the pull of the vertical component of the Earth's magnetic field
        - b When flying on a heading of N, a turn to the E results in:



            1. The aircraft banking to the right and the compass card tilting to the right
            2. Then, the vertical component pulls the N seeking end of the compass to the right
                a. The float rotates, causing the card to rotate toward the W (opposite the turn)
        - c The same happens when turning to the W; the float rotates to the E (opposite)
        - d Remember: When starting a turn from a N heading, the compass lags behind the turn
        - e When flying on a heading of S, a turn to the E results in:
            1. The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)
        - f When turning to the W, the same happens; the float rotates to the W (same direction)
        - g Remember: When starting a turn from a S heading, the compass leads the turn
        - h Remember: UNOS - Undershoot North, Overshoot South
    - Acceleration Error



        - a The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end

- b If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N
- c If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S
- d When flying on a heading of W, the same things happen
- e Remember: ANDS – Accelerate ➔ North, Decelerate ➔ South

e. Oscillation Error
- Oscillation is a combination of all the other errors
  - a It results in the compass card swinging back and forth around the heading being flown
- When setting the HI to the MC, use the average indication

4. Proper Instrument Cross-check Techniques

A. What is Cross-checking?

i. The continuous and logical observation of instruments for attitude and performance information

B. Techniques

i. Using Analog Instrumentation (6-pack)

a. Selected Radial Cross-Check
- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern

b. Inverted-V Cross-Check
- The pilot scans from the attitude indicator down to the turn coordinator, up to the attitude indicator, down to the VSI, and back up to the attitude indicator

c. Rectangular Cross-Check
- The pilot scans across the top three instruments (airspeed indicator, attitude indicator, and altimeter) and then drops down to scan the bottom three instruments (VSI, heading indicator, and turn coordinator)
- This scan follows a rectangular path; clockwise or counterclockwise is a personal choice

ii. Using an Electronic Flight Display

a. Selected Radial Cross-Check
- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern
- The radial scan pattern works well for scanning the PFD
  - a The close proximity of the instrument tape displays necessitates very little eye movement in order to focus on the desired instrument
- Performing the Scan
  - a Start in the center, on the attitude indicator. Note the pitch attitude and then transition up to the slip/skid indicator and roll pointer to ensure the desired bank is set. Return to the attitude indicator. Scan left to the airspeed tape, verify it is as desired and return to the center of the display (attitude indicator). Scan to the right and verify the desired altitude is being maintained. Once verified, return to the center of the display, then transition down to the heading indicator to verify the desired heading. Once confirmed, return to the center of the display

b It is also important to include the engine indications in the scan
    1. Individualized scan methods may require adjustment if engine indications are presented on a separate MFD
c Another critical component to include in the scan is the moving map display located on the MFD

RISK MANAGEMENT

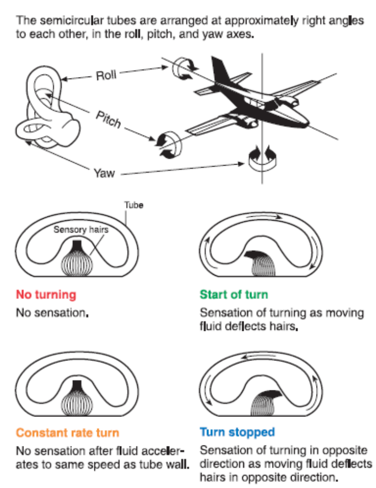
The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Instrument Flying Hazards to Include Failure to Maintain VFR, Spatial Disorientation, Loss of Control, Fatigue, Stress, and Emergency Off Airport Landings

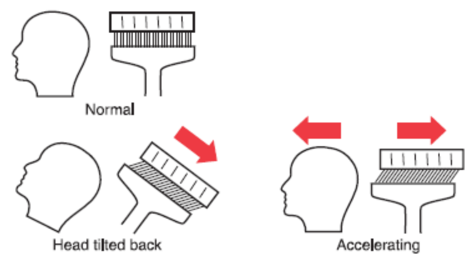
A. Failure to Maintain VFR
   i. Risks include disorientation, loss of control, getting lost, icing conditions, excessive stress, midair collision, and more
   ii. These risks can be prevented through thorough preflight planning and weather briefings
      a. A few days prior to the planned flight check the expected weather
         - Monitor the weather reports in the days leading up to the planned flight
      b. The day before the flight analyze the aviation weather products
      c. The day of the flight reexamine the aviation weather products and get a weather brief
      d. If the weather is not at least VFR do not go
         - Apply your own weather minimums based on experience, proficiency, comfort level, and safety
   iii. In the case unexpected weather puts you and the aircraft in a situation that is less than VFR use all capabilities available to safely exit the conditions, for example:
      a. Flight Instruments – transition from visual references to instrument references. Trust the instruments to avoid spatial disorientation
         - Use the autopilot, if available, in order to further decrease the risk of spatial disorientation
      b. ATC
         - Inform ATC of the conditions and request assistance in finding VMC conditions
      c. GPS
         - The moving map display can be a great tool to maintain situational awareness
         - If satellite weather is available, use it to your advantage

B. Spatial Disorientation
   i. Explanation
      a. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point, disorientation is the lack of orientation
      b. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
      c. The body uses three systems to ascertain orientation and movement in space
         - Visual: The eye, by far the largest source of information
         - Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
         - Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
      d. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving

ii. Relation to flight
   a. Flying can result in conflicting information being sent to the brain, leading to disorientation
   b. Visual System (eyes)
      - Flight in VMC
         a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
      - Flight in IMC
         a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
   c. Vestibular System (ears)
      - The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
      - Two major parts: Semicircular Canals and Otolith Organs
      - Semicircular Canals
         a Explanation
            1. Detect angular acceleration
            2. Three tubes at right angles to each other
               a. One on each of the three axes; pitch, roll, and yaw
            3. Each canal is filled with a fluid
            4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves
         b How they work: In a Turn
            1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
               a. Glass of water illustration: wall is moving but water is not
            2. The ear only detects turns of a short duration
               a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
               b. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)
                  i. Glass of water illustration: water matches the speed of the glass
               c. When the turning stops, the ear canal stops moving but the fluid does not
                  i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight
            3. This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.



- Otolith Organs
    a Explanation
        1. Detect linear acceleration/gravity
        2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
        3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift



    b Acceleration
        1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

d. Postural System (nerves)
- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- Acceleration will be felt as the pilot is pushed back into the seat
- False Sensations
    a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
        1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
    b Turbulence can create motions that confuse the brain
    c Fatigue or illness can exacerbate these sensations

iii. The Leans

a. As mentioned above, when the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning. If the turn is entered too slowly to stimulate the motion sensing system and abrupt correction back to straight-and-level flight, the correction can create the illusion of banking in the opposite direction

iv. Countering the sensations

a. Prevention is usually the best remedy for spatial disorientation
- Unless a pilot has many hours of training in instrument flight, flights should be avoided in reduced visibility or at night when the horizon is not visible

b. Trust the Instruments
- A pilot can reduce susceptibility to disorienting illusions through training and awareness and learning to rely totally on flight instruments
    a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments

c. Use the Autopilot
- The autopilot can be an excellent tool in combatting a loss of situational awareness

d. Ask for help
- Confess the problem and request help
    a If you have another pilot in the aircraft confess that you're disoriented and transfer the controls
        1. Don't tell them what you're experiencing (it may cause them to see/feel the same thing). Simply tell them you're disoriented and transfer them the controls

C. Loss of Control
    i. In the case of instrument flying, especially with very little experience, it is easy to become spatially disoriented and/or end up in an unusual attitude
    ii. Trust the Instruments
        a. The body, eyes, and mind can be tricked without visual references. Trust the instruments and use the basic instrument maneuvers to maintain control
            - Establish, trim, crosscheck, adjust
    iii. Autopilot
        a. Use the autopilot to help reduce the chance of disorientation and a loss of control

D. Fatigue
    i. General
        a. Effects of Fatigue
            - Degradation of attention and concentration
            - Impaired coordination
            - Decreased ability to communicate
            - These factors seriously influence the ability to make effective decisions
                a Fatigue is frequently associated with pilot error
        b. Causes of Fatigue
            - Sleep Loss
            - Exercise, physical work
            - Factors such as stress and prolonged performance of cognitive work result in mental fatigue
        c. Fatigue can increase susceptibility to, and exacerbate spatial disorientation
    ii. Types of Fatigue (Acute and Chronic)
        a. Acute
            - Short term and is a normal occurrence in everyday living. The kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep
            - Rest after exertion and 8 hours of sleep ordinarily cures this condition
            - A special type of acute fatigue is skill fatigue. This type of fatigue has two main effects on performance
                a Timing Disruption: appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integral activity
                b Disruption of the perceptual field: concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements
            - Causes of Acute Fatigue
                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 and adequate rest and sleep
                    1. A well-balanced diet prevents the body from needing to consume its own tissue as an energy source
                    2. Adequate rest maintains the body's store of vital energy

- If suffering from acute fatigue, stay on the ground
  - a If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects
  - b Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day

b. Chronic
- Extends over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible
  - a Continuous high stress levels produce chronic fatigue and it is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician
- Symptoms
  - a Weakness
  - b Tiredness
  - c Palpitations of the heart
  - d Breathlessness
  - e Headaches
  - f Irritability

c. Pilots who suspect they are suffering from chronic fatigue should consult a physician

E. Stress
- i. The 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
  - a. Physical stress (noise or vibration)
  - b. Physiological stress (fatigue)
  - c. Psychological stress (difficult work or personal situations)
- iv. Categories of Stress
  - 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. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
  - b. Causes
    - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
  - c. Pilots experiencing this level of stress are not safe and should not fly

F. Emergency Off Airport Landings
- i. Preflight Planning
  - a. Off airport landings in instrument conditions can be very stressful
  - b. Preflight planning, and being aware of the terrain, roads, airports, etc. can be of great assistance in a case like this

            - The pilot, if familiar with the area can navigate toward known flat areas or lines of communication (primarily roads) to increase the chance of being seen
    ii. ATC
        a. Communicate with ATC, advise them of the situation, inform them where you are, and where you're planning to go. Keep them updated as you progress.
        b. ATC can direct other aircraft or search and rescue to your location
    iii. Navigating in Instrument Conditions
        a. Without visual reference to the ground and potential landing spots navigating to a safe off airport landing area can be very difficult. Use any means available, examples include:
            - ATC may be able to provide vectors
            - GPS may indicate areas of low terrain or road
            - Sectional/terminal map. If the pilot is aware of his or her last known location and approximate heading may be able to point the aircraft in the direction of a safe landing area

2. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."

B. What actually constitutes an emergency can vary based on the situation
    i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination

C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
    i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.

D. Hesitation/Fear of Declaring
    i. For whatever reason, there is often a hesitation to declare an emergency
        a. In some circumstances, pilots can feel that by declaring an emergency means they failed
    ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
        a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate
            - Err on the side of caution
    iii. No one knows you have an emergency until you tell them
        a. ATC can't do anything to help you if they don't know there's a problem
        b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
        c. It gives you additional help
    iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
        a. Do not risk lives because you don't want to declare an emergency
            - Your pride has no place in a real or potential emergency situation
    v. Do not ever declare an emergency simply for priority
    vi. AvWeb: Declaring an Emergency and what happens next

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
    i. Operation Lights On
        a. A voluntary FAA safety program to enhance the see and avoid concept

   b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other’s right has the right-of-way.
      - If they are different categories:
         a A balloon has the right of way over any other category
         b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
         c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
         d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
   c. Approaching Head-on
      - Each pilot shall alter course to the right
   d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
   e. Landing
      - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
         a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
      - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
         a Don’t take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field

- Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield

a. Study sectionals and terminal area charts

b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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

- Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing

b. Become familiar with any obstacles on the approach and departure path

c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)

d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen

e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers

a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see

- Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires

a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)

b. These wires and lines may or may not be lighted

c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft

a. Ensure proper clearance between the aircraft and obstacle

- If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. During spins, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
    a. Flying takes precedence
        - Aviate, Navigate, Communicate
        - In the case of a real-life spin recovery, it is essential the pilot safely recover the aircraft
ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
    a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin
iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important in preventing stalls and spins. A loss of situational awareness can lead to a stall, spin, mishap, or incursion on the ground or in the air
    i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    ii. Maintain situational awareness
        a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
    i. Attention needs to be divided between the various required tasks
        a. No one responsibility should take your full attention full more than a short period
            - Continually move between tasks to ensure everything is being taken care of
            - By effectively dividing attention, the pilot can deter the chance of a stall and spin
        b. Safety is your number one priority
            - Aviate, Navigate, Communicate
    ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        a. Checklists are extremely helpful in properly managing tasks
    iii. Recognize when you are getting behind the aircraft, 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
    iv. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Maintain straight-and-level flight using proper instrument cross-check and interpretation, and coordinated control application.
2. Maintain altitude ±200 feet, heading ±20°, and airspeed ±10 knots.

VIII.B. Constant Airspeed Climbs

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Flight Instruments Sensitivity, Limitations, and Potential Errors in Unusual Attitudes**
    - A. Attitude Indicator
        - i. Spillable Indicators
            - a. Do not depend on the attitude indicator during an unusual attitude if it is the spillable type, because its upset limits may have been exceeded or it may have become inoperative due to mechanical malfunction
        - ii. Nonspillable Indicators
            - a. If operating properly, errors up to 5 degrees of pitch and bank may result and indications are very difficult to interpret in extreme attitudes
    - B. Heading Indicator
        - i. Verify the heading indicator against the magnetic compass
            - a. This can be difficult in an unusual attitude since the compass may be swinging somewhat wildly. Wait for it to settle to ensure the heading indicator is accurate and has not precessed
    - C. Be aware of any limitations, errors, etc. associated with your specific flight instruments
2. **Flight Instrument Correlation (Pitch/Bank Instruments)**
    - A. Pitch Instruments (Constant Airspeed, Straight Climb)
        - i. The Instruments
            - a. Altimeter
            - b. Attitude Indicator
            - c. Vertical Speed Indicator (VSI)
        - ii. Procedure for Basic Instrument Maneuvers
            - a. Establish
                - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, a straight climb at a constant airspeed
                - Pitch Instruments: Set the attitude indicator at the desired pitch attitude
            - b. Trim
                - Trim the pitch control pressure for hands off flight
            - c. Crosscheck
                - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
                    - a The altimeter should indicate a steady climb
                    - b The VSI should indicate a normal climb rate
                    - c The airspeed should be constant
                        1. Increasing airspeed can be a sign of a low pitch attitude (with no other changes in power, configuration, etc.). Decreasing airspeed is a sign of a high pitch attitude
            - d. Adjust
                - Make adjustments corresponding to the amount of change desired
                - 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

e. Repeat the steps. After making an adjustment, trim the aircraft, crosscheck the instruments, and readjust if necessary…

B. Bank Instruments (Constant Heading/Straight Flight)

i. The Instruments

a. Heading Indicator

b. Attitude Indicator

c. Turn Coordinator

d. Magnetic Compass

ii. Procedure for Basic Instrument Maneuvers

a. Establish
- Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, straight flight during a constant airspeed climb
- Bank Instruments: Set the attitude indicator for wings level flight

b. Trim
- Trim the pitch control pressure for hands off flight
- Rarely do general aviation aircraft have bank trim

c. Crosscheck
- Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
  - a The heading indicator should indicate a steady heading (straight flight)
  - b The magnetic compass should also indicate a steady heading (straight flight)
  - c The turn coordinator should indicate zero rate of turn and coordinated flight

d. Adjust
- If the airplane is banking in one direction or the other, the bank should be readjusted to put the wings level on the attitude indicator
- 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
- It's important not to correct heading errors solely by yawing or rolling the airplane
  - a Maintain a coordinated flight condition with coordinated aileron and rudder
  - b Uncoordinated flight creates drag, slowing the aircraft since the fuselage is put into the relative wind

C. Constant Airspeed Climbing Turn

i. Adjust bank for a turn as described below

D. Pitch, Bank, and Power Settings for Constant Airspeed Climbs

i. Straight Climb

Pitch + Power = Desired Performance
10º Nose Up + Full Power = Constant Airspeed Climb

Pitch		Bank	
A/I	10º Nose Up	A/I	Wings Level
Alt	Climbing	DG	Constant
VSI	Positive Climb	Compass	Constant
A/S	Constant Climb AS	T/C	Level/Coordinated

a. Establish – Raise the nose of the aircraft to the approximate pitch attitude for the desired climb speed
   - 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

d. Adjust – Correct any performance errors as necessary and retrim the airplane, then crosscheck again
   - a Adjust the pitch attitude to maintain the desired climb airspeed (1 bar or ½ bar width movements)

e. Leveling Off
   - Lead the altitude by 10% of the vertical speed (EX: 500 fpm climb is led by 50')
   - Use the same procedure to level off the plane
     - a Establish – Reduce power and apply smooth steady elevator pressure toward a level attitude
     - b Then Trim the airplane and maintain straight and level flight
     - c Crosscheck – VSI, Altimeter and attitude indicator should show level flight

ii. Constant Airspeed Turning Climb

Pitch + Power = Desired Performance
10º Nose Up + Full Power = Constant Airspeed Climb

Pitch		Bank	
A/I	10º Nose Up	A/I	15º Bank
Alt	Climbing	DG	Turning
VSI	Positive Climb	Compass	Turning
A/S	Constant Climb AS	T/C	Turn/Coordinated

a. Establish – Raise the nose of the aircraft to the approximate pitch attitude for the desired climb speed and established the desired bank angle (in this case 15 degrees)
   - 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

d. Adjust – Correct any performance errors as necessary and retrim the airplane, then crosscheck again
   - a Adjust the pitch attitude to maintain the desired climb airspeed (1 bar or ½ bar width movements)

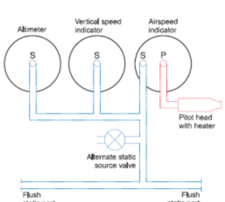
e. Leveling Off
   - Lead the altitude by 10% of the vertical speed (EX: 500 fpm climb is led by 50')
   - Use the same procedure to level off the plane
     - a Establish – Reduce power and apply smooth elevator pressure toward a level attitude
     - b Trim the airplane and maintain straight and level flight
     - c Crosscheck – Vertical speed, Altimeter and attitude indicator should show level flight

3. Flight Instrument Function and Operation

A. Pitot-Static System (Altimeter, Vertical Speed Indicator, Airspeed Indicator)

i. 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

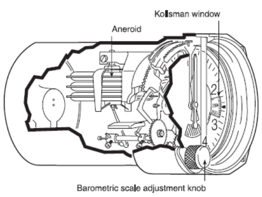
c. Pitot Pressure (impact air pressure) is measured through a tube pointed into the relative wind
    - Ram air pressure used to measure airspeed

d. The Pitot Tube connects to the airspeed indicator; the Static Port connects to all 3 instruments

ii. 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'
    - 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. If the pilot does not change the altimeter settings, the altimeter will indicate lower
        2. 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, lowering true alt
    - b The opposite applies from Low pressure to High pressure
- REMEMBER: From hot to cold, or from high to low, look out below!

iii. Vertical Speed Indicator

a. A rate-of-pressure change instrument giving an indication of deviation from a constant pressure level

b. Principle of Operation

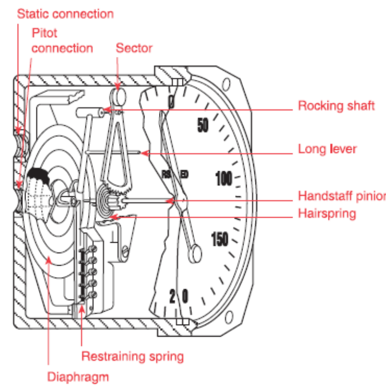
- Inside the instrument case is an aneroid
    - a Both the aneroid and the inside of the instrument case are vented to the static system
        1. But, the case is vented through a calibrated orifice that causes the pressure inside to change more slowly than that inside the aneroid
- As the aircraft 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

iv. 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 (the difference between pitot and static pressure)

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 or static decreases, the diaphragm expands and vice versa
     a A rocking shaft and set of gears drives the AS needle



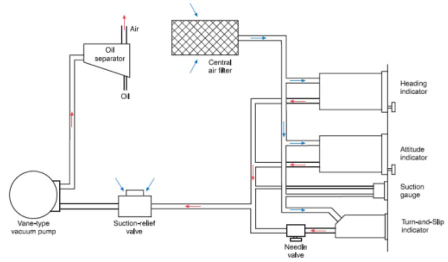
B. Gyroscopic System (Attitude & Heading Indicators, Turn Coordinator)

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^{o} from that point in the direction of rotation

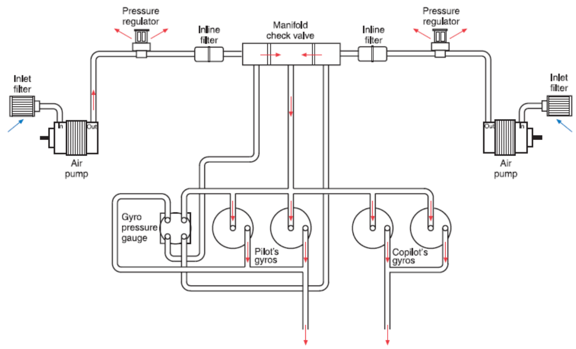
b. The instruments contain a gyro (small wheel with its weight concentrated around its periphery)
   - When spun at a high speed, the wheel becomes rigid, resisting any attempt to tilt or turn in any direction other than around its spin axis
     a Attitude/Heading instruments operate on the principle 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 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
        - c Some attitude indicators can tumble (lose their rigidity) if the aircraft pitch/bank attitude reaches a certain point. Beyond this point the attitude indicator may be unreliable

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
  - Precession can cause errors over time

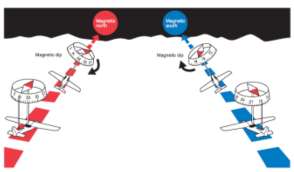
iv. Turn Indicators
a. Rate instruments operate on the principle of precession
b. Turn-and-Slip Indicator
  - A small gyro mounted in a single gimbal
    a Gyro spin axis is parallel to the lateral axis; the gimbal axis is parallel to the longitudinal
  - Yawing, or rotating about the vertical axis, produces a force in the horizontal plane
    a This, due to precession, causes the gyro and its gimbal to rotate about the gimbal axis
  - Inclinometer
    a A black glass ball sealed inside a curved glass tube that is partially filled with a liquid
    b When straight and level, there is no inertia acting on the ball and it remains centered
    c In a turn with too steep a bank angle, gravity exceeds inertia and the ball rolls inward
    d In a turn with too shallow of bank, inertia exceeds gravity and the ball rolls outward
    e Only indicates the relationship between the angle of bank and the rate of yaw
c. Turn Coordinator
  - Similar to the Turn and Slip Indicator, but its gimbal frame is angled upward about 30^{o} from the longitudinal axis of the airplane
    a This allows it to sense both roll and yaw (not just yaw like the T&S Indicator)
  - The inclinometer is the same, and called a coordination ball
    a Shows the relationship between the bank angle and rate of yaw
      1. Skidding when the ball rolls outside the turn
      2. Slipping when the ball rolls inside the turn

C. Magnetic Compass

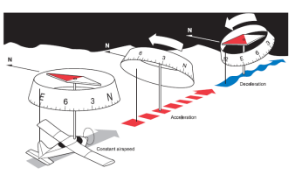
i. Operation
a. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid
b. A card is wrapped around the float and visible from the outside with a lubber line
  - Lubber Line: The reference line used in a magnetic compass or heading indicator
c. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup
  - The buoyancy of the float takes most of the weight off the pivot
  - The jewel and pivot type mounting allows the float to rotate and tilt up to approximately 18^{o}
d. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line
  - The pilot sees the card from its backside
    a The reason for this is the card remains stationary and the housing/pilot turn around it

ii. Errors
a. Variation
  - Caused by the difference in the locations of the magnetic and geographic north pole
  - The north magnetic pole is not collocated with the geographic north pole
    a The difference between true and magnetic directions
  - Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
  - Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation
b. Deviation
  - Caused by local magnetic fields within the aircraft; different on each heading
  - The magnets in a compass align with any magnetic field

        a Local magnets caused by electrical currents will conflict with the Earth's field
    - Deviation varies by heading and is shown on a compass correction card
  c. Finding the Compass Course
    - True Course ± Variation = Magnetic Course ± Deviation = Compass Course
    - Remember: East is Least, West is Best
        a Subtract variation from true course, Add variation to true course
  d. Dip Errors
    - What's Going On
        a The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
            1. At both poles, the lines are perpendicular to the surface
            2. Over the equator, the lines are parallel to the surface
        b The magnets align with these fields and near the poles they dip, tilt, the float/card
        c The float is balanced with a small dip compensating weight, so it stays relatively level
    - Northerly Turning Error
        a Caused by the pull of the vertical component of the Earth's magnetic field
        b When flying on a heading of N, a turn to the E results in:



            1. The aircraft banking to the right and the compass card tilting to the right
            2. Then, the vertical component pulls the N seeking end of the compass to the right
                a. The float rotates, causing the card to rotate toward the W (opposite the turn)
        c The same happens when turning to the W; the float rotates to the E (opposite)
        d Remember: When starting a turn from a N heading, the compass lags behind the turn
        e When flying on a heading of S, a turn to the E results in:
            1. The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)
        f When turning to the W, the same happens; the float rotates to the W (same direction)
        g Remember: When starting a turn from a S heading, the compass leads the turn
        h Remember: UNOS - Undershoot North, Overshoot South
    - Acceleration Error



        a The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end
        b If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N
        c If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S
        d When flying on a heading of W, the same things happen
        e Remember: ANDS – Accelerate → North, Decelerate → South
  e. Oscillation Error
    - Oscillation is a combination of all the other errors
        a It results in the compass card swinging back and forth around the heading being flown
    - When setting the HI to the MC, use the average indication

4. Proper Instrument Cross-check Techniques

A. What is Cross-checking?
  i. The continuous and logical observation of instruments for attitude and performance information

B. Techniques
  i. Using Analog Instrumentation (6-pack)
    a. Selected Radial Cross-Check

- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern

b. Inverted-V Cross-Check
- The pilot scans from the attitude indicator down to the turn coordinator, up to the attitude indicator, down to the VSI, and back up to the attitude indicator

c. Rectangular Cross-Check
- The pilot scans across the top three instruments (airspeed indicator, attitude indicator, and altimeter) and then drops down to scan the bottom three instruments (VSI, heading indicator, and turn coordinator)
- This scan follows a rectangular path; clockwise or counterclockwise is a personal choice

ii. Using an Electronic Flight Display

a. Selected Radial Cross-Check
- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern
- The radial scan pattern works well for scanning the PFD
  - a The close proximity of the instrument tape displays necessitates very little eye movement in order to focus on the desired instrument
- Performing the Scan
  - a Start in the center, on the attitude indicator. Note the pitch attitude and then transition up to the slip/skid indicator and roll pointer to ensure the desired bank is set. Return to the attitude indicator. Scan left to the airspeed tape, verify it is as desired and return to the center of the display (attitude indicator). Scan to the right and verify the desired altitude is being maintained. Once verified, return to the center of the display, then transition down to the heading indicator to verify the desired heading. Once confirmed, return to the center of the display
  - b It is also important to include the engine indications in the scan
    1. Individualized scan methods may require adjustment if engine indications are presented on a separate MFD
  - c Another critical component to include in the scan is the moving map display located on the MFD

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Instrument Flying Hazards to Include Failure to Maintain VFR, Spatial Disorientation, Loss of Control, Fatigue, Stress, and Emergency Off Airport Landings

A. Failure to Maintain VFR

i. Risks include disorientation, loss of control, getting lost, icing conditions, excessive stress, midair collision, and more

ii. These risks can be prevented through thorough preflight planning and weather briefings

a. A few days prior to the planned flight check the expected weather
    - Monitor the weather reports in the days leading up to the planned flight
b. The day before the flight analyze the aviation weather products
c. The day of the flight reexamine the aviation weather products and get a weather brief
d. If the weather is not at least VFR do not go
    - Apply your own weather minimums based on experience, proficiency, comfort level, and safety

iii. In the case unexpected weather puts you and the aircraft in a situation that is less than VFR use all capabilities available to safely exit the conditions, for example:

a. Flight Instruments – transition from visual references to instrument references. Trust the instruments to avoid spatial disorientation
    - Use the autopilot, if available, in order to further decrease the risk of spatial disorientation
b. ATC
    - Inform ATC of the conditions and request assistance in finding VMC conditions
c. GPS
    - The moving map display can be a great tool to maintain situational awareness
    - If satellite weather is available, use it to your advantage

B. Spatial Disorientation

i. Explanation

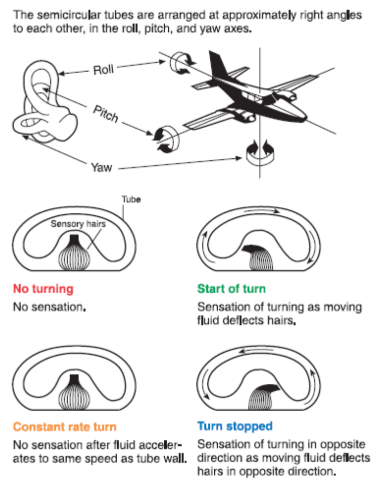
a. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point, disorientation is the lack of orientation
b. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
c. The body uses three systems to ascertain orientation and movement in space
    - Visual: The eye, by far the largest source of information
    - Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
    - Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
d. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving

ii. Relation to flight

a. Flying can result in conflicting information being sent to the brain, leading to disorientation
b. Visual System (eyes)
    - Flight in VMC
        - a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
    - Flight in IMC
        - a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
c. Vestibular System (ears)
    - The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
    - Two major parts: Semicircular Canals and Otolith Organs
    - Semicircular Canals
        - a Explanation
            1. Detect angular acceleration

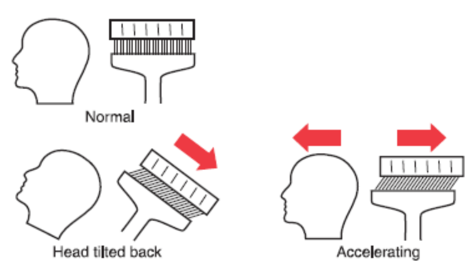
2. Three tubes at right angles to each other
    a. One on each of the three axes; pitch, roll, and yaw
3. Each canal is filled with a fluid
4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves

b How they work: In a Turn
1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
    a. Glass of water illustration: wall is moving but water is not
2. The ear only detects turns of a short duration
    a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
    b. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)
        i. Glass of water illustration: water matches the speed of the glass
    c. When the turning stops, the ear canal stops moving but the fluid does not
        i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight
3. This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.



- Otolith Organs
    a Explanation
    1. Detect linear acceleration/gravity
    2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
    3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift

    b Acceleration
    1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward



d. Postural System (nerves)
- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- Acceleration will be felt as the pilot is pushed back into the seat

- False Sensations
  - a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
    1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
  - b Turbulence can create motions that confuse the brain
  - c Fatigue or illness can exacerbate these sensations

iii. The Leans

a. As mentioned above, when the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning. If the turn is entered too slowly to stimulate the motion sensing system and abrupt correction back to straight-and-level flight, the correction can create the illusion of banking in the opposite direction

iv. Countering the sensations

a. Prevention is usually the best remedy for spatial disorientation
- Unless a pilot has many hours of training in instrument flight, flights should be avoided in reduced visibility or at night when the horizon is not visible

b. Trust the Instruments
- A pilot can reduce susceptibility to disorienting illusions through training and awareness and learning to rely totally on flight instruments
  - a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments

c. Use the Autopilot
- The autopilot can be an excellent tool in combatting a loss of situational awareness

d. Ask for help
- Confess the problem and request help
  - a If you have another pilot in the aircraft confess that you're disoriented and transfer the controls
    1. Don't tell them what you're experiencing (it may cause them to see/feel the same thing). Simply tell them you're disoriented and transfer them the controls

C. Loss of Control

i. In the case of instrument flying, especially with very little experience, it is easy to become spatially disoriented and/or end up in an unusual attitude

ii. Trust the Instruments

a. The body, eyes, and mind can be tricked without visual references. Trust the instruments and use the basic instrument maneuvers to maintain control
- Establish, trim, crosscheck, adjust

iii. Autopilot

a. Use the autopilot to help reduce the chance of disorientation and a loss of control

D. Fatigue

i. General

a. Effects of Fatigue
- Degradation of attention and concentration
- Impaired coordination
- Decreased ability to communicate
- These factors seriously influence the ability to make effective decisions
  - a Fatigue is frequently associated with pilot error

b. Causes of Fatigue
    - Sleep Loss
    - Exercise, physical work
    - Factors such as stress and prolonged performance of cognitive work result in mental fatigue

c. Fatigue can increase susceptibility to, and exacerbate spatial disorientation

ii. Types of Fatigue (Acute and Chronic)

a. Acute
    - Short term and is a normal occurrence in everyday living. The kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep
    - Rest after exertion and 8 hours of sleep ordinarily cures this condition
    - A special type of acute fatigue is skill fatigue. This type of fatigue has two main effects on performance
        - a Timing Disruption: appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integral activity
        - b Disruption of the perceptual field: concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements
    - Causes of Acute Fatigue
        - 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 and adequate rest and sleep
            1. A well-balanced diet prevents the body from needing to consume its own tissue as an energy source
            2. Adequate rest maintains the body's store of vital energy
    - If suffering from acute fatigue, stay on the ground
        - a If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects
        - b Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day

b. Chronic
    - Extends over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible
        - a Continuous high stress levels produce chronic fatigue and it is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician
    - Symptoms
        - a Weakness
        - b Tiredness
        - c Palpitations of the heart
        - d Breathlessness
        - e Headaches
        - f Irritability

c. Pilots who suspect they are suffering from chronic fatigue should consult a physician

E. Stress
  i. The 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
    a. Physical stress (noise or vibration)
    b. Physiological stress (fatigue)
    c. Psychological stress (difficult work or personal situations)
  iv. Categories of Stress
    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. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
    b. Causes
      - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
    c. Pilots experiencing this level of stress are not safe and should not fly

F. Emergency Off Airport Landings
  i. Preflight Planning
    a. Off airport landings in instrument conditions can be very stressful
    b. Preflight planning, and being aware of the terrain, roads, airports, etc. can be of great assistance in a case like this
      - The pilot, if familiar with the area can navigate toward known flat areas or lines of communication (primarily roads) to increase the chance of being seen
  ii. ATC
    a. Communicate with ATC, advise them of the situation, inform them where you are, and where you're planning to go. Keep them updated as you progress.
    b. ATC can direct other aircraft or search and rescue to your location
  iii. Navigating in Instrument Conditions
    a. Without visual reference to the ground and potential landing spots navigating to a safe off airport landing area can be very difficult. Use any means available, examples include:
      - ATC may be able to provide vectors
      - GPS may indicate areas of low terrain or road
      - Sectional/terminal map. If the pilot is aware of his or her last known location and approximate heading may be able to point the aircraft in the direction of a safe landing area

2. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."

B. What actually constitutes an emergency can vary based on the situation

            i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination
   C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
      i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.
   D. Hesitation/Fear of Declaring
      i. For whatever reason, there is often a hesitation to declare an emergency
         a. In some circumstances, pilots can feel that by declaring an emergency means they failed
      ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
         a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate
            - Err on the side of caution
      iii. No one knows you have an emergency until you tell them
         a. ATC can't do anything to help you if they don't know there's a problem
         b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
         c. It gives you additional help
      iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
         a. Do not risk lives because you don't want to declare an emergency
            - Your pride has no place in a real or potential emergency situation
      v. Do not ever declare an emergency simply for priority
      vi. AvWeb: Declaring an Emergency and what happens next

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires
   A. Collision Avoidance
      i. Operation Lights On
         a. A voluntary FAA safety program to enhance the see and avoid concept
         b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
      ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
            - If they are different categories:
               a A balloon has the right of way over any other category
               b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
               c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
               d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
         c. Approaching Head-on
            - Each pilot shall alter course to the right
         d. Overtaking

- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
   - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
     - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
     - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary
   c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
   a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
      - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
   a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
   b. Become familiar with any obstacles on the approach and departure path
   c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
   d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
   e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers
   a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
      - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires
   a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
   b. These wires and lines may or may not be lighted
   c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
   a. Ensure proper clearance between the aircraft and obstacle
      - If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. During spins, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
      a. Flying takes precedence
         - Aviate, Navigate, Communicate
         - In the case of a real-life spin recovery, it is essential the pilot safely recover the aircraft
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin
   iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
      a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important in preventing stalls and spins. A loss of situational awareness can lead to a stall, spin, mishap, or incursion on the ground or in the air
   i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   ii. Maintain situational awareness
      a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management

i. Attention needs to be divided between the various required tasks
    a. No one responsibility should take your full attention full more than a short period
        - Continually move between tasks to ensure everything is being taken care of
        - By effectively dividing attention, the pilot can deter the chance of a stall and spin
    b. Safety is your number one priority
        - Aviate, Navigate, Communicate

ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks

iii. Recognize when you are getting behind the aircraft, 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

iv. Don’t give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Transition to the climb pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
2. Demonstrate climbs solely by reference to instruments at a constant airspeed to specific altitudes in straight flight and turns.
3. Level off at the assigned altitude and maintain altitude ±200 feet, heading ±20° and airspeed ±10 knots.

VIII.C. Constant Airspeed Descents

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Flight Instruments Sensitivity, Limitations, and Potential Errors in Unusual Attitudes**
    - A. Attitude Indicator
        - i. Spillable Indicators
            - a. Do not depend on the attitude indicator during an unusual attitude if it is the spillable type, because its upset limits may have been exceeded or it may have become inoperative due to mechanical malfunction
        - ii. Nonspillable Indicators
            - a. If operating properly, errors up to 5 degrees of pitch and bank may result and indications are very difficult to interpret in extreme attitudes
    - B. Heading Indicator
        - i. Verify the heading indicator against the magnetic compass
            - a. This can be difficult in an unusual attitude since the compass may be swinging somewhat wildly. Wait for it to settle to ensure the heading indicator is accurate and has not precessed
    - C. Be aware of any limitations, errors, etc. associated with your specific flight instruments
2. **Flight Instrument Correlation (Pitch/Bank Instruments)**
    - A. Pitch Instruments (Constant Airspeed, Straight Climb)
        - i. The Instruments
            - a. Altimeter
            - b. Attitude Indicator
            - c. Vertical Speed Indicator (VSI)
        - ii. Procedure for Basic Instrument Maneuvers
            - a. Establish
                - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, a straight descent at a constant airspeed
                - Pitch Instruments: Set the attitude indicator at the desired pitch attitude
            - b. Trim
                - Trim the pitch control pressure for hands off flight
            - c. Crosscheck
                - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
                    - a The altimeter should indicate a steady descent
                    - b The VSI should indicate a normal descent rate
                    - c The airspeed should be constant
                        1. Increasing airspeed can be a sign of a low pitch attitude (with no other changes in power, configuration, etc.). Decreasing airspeed is a sign of a high pitch attitude
            - d. Adjust
                - Make adjustments corresponding to the amount of change desired
                - 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

e. Repeat the steps. After making an adjustment, trim the aircraft, crosscheck the instruments, and readjust if necessary…

B. Bank Instruments (Constant Heading/Straight Flight)
   i. The Instruments
      a. Heading Indicator
      b. Attitude Indicator
      c. Turn Coordinator
      d. Magnetic Compass
   ii. Procedure for Basic Instrument Maneuvers
      a. Establish
         - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, straight flight during a constant airspeed climb
         - Bank Instruments: Set the attitude indicator for wings level flight
      b. Trim
         - Trim the pitch control pressure for hands off flight
         - Rarely do general aviation aircraft have bank trim
      c. Crosscheck
         - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
            a The heading indicator should indicate a steady heading (straight flight)
            b The magnetic compass should also indicate a steady heading (straight flight)
            c The turn coordinator should indicate zero rate of turn and coordinated flight
      d. Adjust
         - If the airplane is banking in one direction or the other, the bank should be readjusted to put the wings level on the attitude indicator
         - 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
         - It's important not to correct heading errors solely by yawing or rolling the airplane
            a Maintain a coordinated flight condition with coordinated aileron and rudder
            b Uncoordinated flight creates drag, slowing the aircraft since the fuselage is put into the relative wind

C. Constant Airspeed Descending Turn
   i. Adjust bank for a turn as described below

D. Pitch, Bank, and Power Settings for Constant Airspeed Descents
   i. Straight Descent

Pitch + Power = Desired Performance
3° Nose Down + Idle Power = Constant Airspeed Descent

Pitch		Bank	
A/I	3° Nose Down	A/I	Wings Level
Alt	Descending	DG	Constant
VSI	Constant Rate	Compass	Constant
A/S	Constant AS	T/C	Level/Coordinated

a. Establish – Lower the nose of the aircraft to the approximate pitch attitude for the desired descent speed
   - As the airspeed approaches the desired descent speed, set the power to the descent setting

b. Trim – Trim to relieve the control pressures

c. Crosscheck

d. Adjust – Correct any performance errors as necessary and retrim the airplane, then crosscheck again
   a Adjust the pitch attitude to maintain the desired descent airspeed (1 bar or ½ bar width movements)

e. Leveling Off
   - Lead the altitude by 10% of the vertical speed (EX: 500 fpm descent is led by 50')
   - Use the same procedure to level off the plane
     a Establish – Increase power and apply smooth steady elevator pressure toward a level attitude
     b Then Trim the airplane and maintain straight and level flight
     c Crosscheck – VSI, Altimeter and attitude indicator should show level flight

ii. Constant Airspeed Turning Climb

Pitch + Power = Desired Performance
3º Nose Down + Idle Power = Constant Airspeed Descent

Pitch		Bank	
A/I	3º Nose Down	A/I	15º Bank
Alt	Descending	DG	Turning
VSI	Constant Rate	Compass	Turning
A/S	Constant AS	T/C	Turn/Coordinated

a. Establish – Lower the nose of the aircraft to the approximate pitch attitude for the desired descent speed and established the desired bank angle (in this case 15 degrees)
   - As the airspeed approaches the desired descent speed, set the power to the descent setting (full)

b. Trim – Trim to relieve the control pressures

c. Crosscheck

d. Adjust – Correct any performance errors as necessary and retrim the airplane, then crosscheck again
   a Adjust the pitch attitude to maintain the desired climb airspeed (1 bar or ½ bar width movements)

e. Leveling Off
   - Lead the altitude by 10% of the vertical speed (EX: 500 fpm descent is led by 50')
   - Use the same procedure to level off the plane
     a Establish – Reduce power and apply smooth elevator pressure toward a level attitude
     b Trim the airplane and maintain straight and level flight
     c Crosscheck – Vertical speed, Altimeter and attitude indicator should show level flight

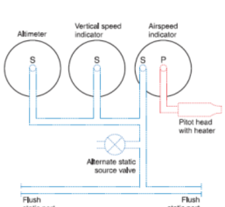
3. Flight Instrument Function and Operation

A. Pitot-Static System (Altimeter, Vertical Speed Indicator, Airspeed Indicator)

i. 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

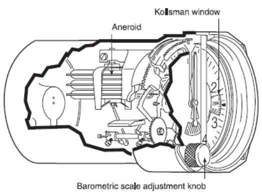
c. Pitot Pressure (impact air pressure) is measured through a tube pointed into the relative wind
   - Ram air pressure used to measure airspeed

d. The Pitot Tube connects to the airspeed indicator; the Static Port connects to all 3 instruments

ii. 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’
     - 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. If the pilot does not change the altimeter settings, the altimeter will indicate lower
       2. 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, lowering true alt
     - b The opposite applies from Low pressure to High pressure
   - REMEMBER: From hot to cold, or from high to low, look out below!

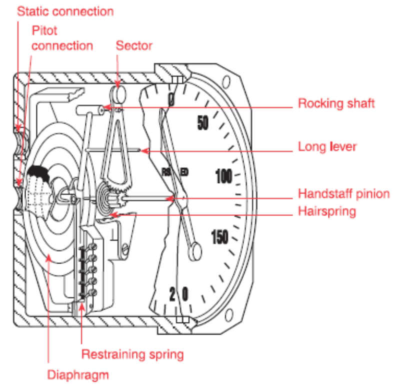
iii. Vertical Speed Indicator

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 instrument 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

iv. 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 (the difference between pitot and static pressure)



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 or static decreases, the diaphragm expands and vice versa
    a A rocking shaft and set of gears drives the AS needle

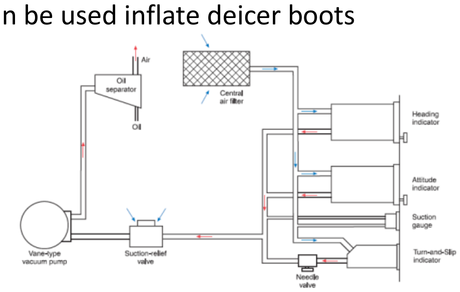
B. Gyroscopic System (Attitude & Heading Indicators, Turn Coordinator)

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

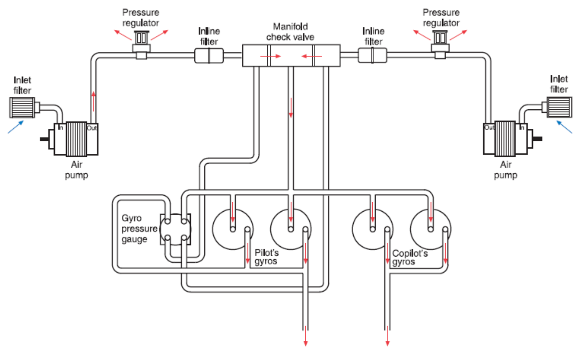
b. The instruments contain a gyro (small wheel with its weight concentrated around its periphery)
  - When spun at a high speed, the wheel becomes rigid, resisting any attempt to tilt or turn in any direction other than around its spin axis
    a Attitude/Heading instruments operate on the principle 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 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
    - c Some attitude indicators can tumble (lose their rigidity) if the aircraft pitch/bank attitude reaches a certain point. Beyond this point the attitude indicator may be unreliable

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
            - Precession can cause errors over time
    iv. Turn Indicators
        a. Rate instruments operate on the principle of precession
        b. Turn-and-Slip Indicator
            - A small gyro mounted in a single gimbal
                a Gyro spin axis is parallel to the lateral axis; the gimbal axis is parallel to the longitudinal
            - Yawing, or rotating about the vertical axis, produces a force in the horizontal plane
                a This, due to precession, causes the gyro and its gimbal to rotate about the gimbal axis
            - Inclinometer
                a A black glass ball sealed inside a curved glass tube that is partially filled with a liquid
                b When straight and level, there is no inertia acting on the ball and it remains centered
                c In a turn with too steep a bank angle, gravity exceeds inertia and the ball rolls inward
                d In a turn with too shallow of bank, inertia exceeds gravity and the ball rolls outward
                e Only indicates the relationship between the angle of bank and the rate of yaw
        c. Turn Coordinator
            - Similar to the Turn and Slip Indicator, but its gimbal frame is angled upward about 30^{o} from the longitudinal axis of the airplane
                a This allows it to sense both roll and yaw (not just yaw like the T&S Indicator)
            - The inclinometer is the same, and called a coordination ball
                a Shows the relationship between the bank angle and rate of yaw
                    1. Skidding when the ball rolls outside the turn
                    2. Slipping when the ball rolls inside the turn
C. Magnetic Compass
    i. Operation
        a. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid
        b. A card is wrapped around the float and visible from the outside with a lubber line
            - Lubber Line: The reference line used in a magnetic compass or heading indicator
        c. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup
            - The buoyancy of the float takes most of the weight off the pivot
            - The jewel and pivot type mounting allows the float to rotate and tilt up to approximately 18^{o}
        d. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line
            - The pilot sees the card from its backside
                a The reason for this is the card remains stationary and the housing/pilot turn around it
    ii. Errors
        a. Variation
            - Caused by the difference in the locations of the magnetic and geographic north pole
            - The north magnetic pole is not collocated with the geographic north pole
                a The difference between true and magnetic directions
            - Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
            - Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation
        b. Deviation
            - Caused by local magnetic fields within the aircraft; different on each heading

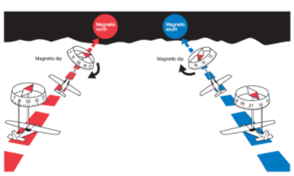
- The magnets in a compass align with any magnetic field
    - a Local magnets caused by electrical currents will conflict with the Earth's field
- Deviation varies by heading and is shown on a compass correction card

c. Finding the Compass Course

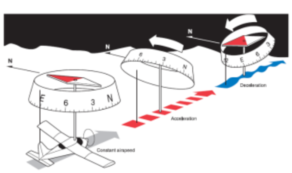
- True Course ± Variation = Magnetic Course ± Deviation = Compass Course
- Remember: East is Least, West is Best
    - a Subtract variation from true course, Add variation to true course

d. Dip Errors

- What's Going On
    - a The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
        1. At both poles, the lines are perpendicular to the surface
        2. Over the equator, the lines are parallel to the surface
    - b The magnets align with these fields and near the poles they dip, tilt, the float/card
    - c The float is balanced with a small dip compensating weight, so it stays relatively level
- Northerly Turning Error
    - a Caused by the pull of the vertical component of the Earth's magnetic field
    - b When flying on a heading of N, a turn to the E results in:



        1. The aircraft banking to the right and the compass card tilting to the right
        2. Then, the vertical component pulls the N seeking end of the compass to the right
            a. The float rotates, causing the card to rotate toward the W (opposite the turn)
    - c The same happens when turning to the W; the float rotates to the E (opposite)
    - d Remember: When starting a turn from a N heading, the compass lags behind the turn
    - e When flying on a heading of S, a turn to the E results in:
        1. The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)
    - f When turning to the W, the same happens; the float rotates to the W (same direction)
    - g Remember: When starting a turn from a S heading, the compass leads the turn
    - h Remember: UNOS - Undershoot North, Overshoot South
- Acceleration Error



    - a The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end
    - b If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N
    - c If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S
    - d When flying on a heading of W, the same things happen
    - e Remember: ANDS – Accelerate → North, Decelerate → South

e. Oscillation Error

- Oscillation is a combination of all the other errors
    - a It results in the compass card swinging back and forth around the heading being flown
- When setting the HI to the MC, use the average indication

4. Proper Instrument Cross-check Techniques

A. What is Cross-checking?

i. The continuous and logical observation of instruments for attitude and performance information

B. Techniques

i. Using Analog Instrumentation (6-pack)

a. Selected Radial Cross-Check
- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern

b. Inverted-V Cross-Check
- The pilot scans from the attitude indicator down to the turn coordinator, up to the attitude indicator, down to the VSI, and back up to the attitude indicator

c. Rectangular Cross-Check
- The pilot scans across the top three instruments (airspeed indicator, attitude indicator, and altimeter) and then drops down to scan the bottom three instruments (VSI, heading indicator, and turn coordinator)
- This scan follows a rectangular path; clockwise or counterclockwise is a personal choice

ii. Using an Electronic Flight Display

a. Selected Radial Cross-Check
- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern
- The radial scan pattern works well for scanning the PFD
  - a The close proximity of the instrument tape displays necessitates very little eye movement in order to focus on the desired instrument
- Performing the Scan
  - a Start in the center, on the attitude indicator. Note the pitch attitude and then transition up to the slip/skid indicator and roll pointer to ensure the desired bank is set. Return to the attitude indicator. Scan left to the airspeed tape, verify it is as desired and return to the center of the display (attitude indicator). Scan to the right and verify the desired altitude is being maintained. Once verified, return to the center of the display, then transition down to the heading indicator to verify the desired heading. Once confirmed, return to the center of the display
  - b It is also important to include the engine indications in the scan
    1. Individualized scan methods may require adjustment if engine indications are presented on a separate MFD
  - c Another critical component to include in the scan is the moving map display located on the MFD

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Instrument Flying Hazards to Include Failure to Maintain VFR, Spatial Disorientation, Loss of Control, Fatigue, Stress, and Emergency Off Airport Landings

A. Failure to Maintain VFR

i. Risks include disorientation, loss of control, getting lost, icing conditions, excessive stress, midair collision, and more

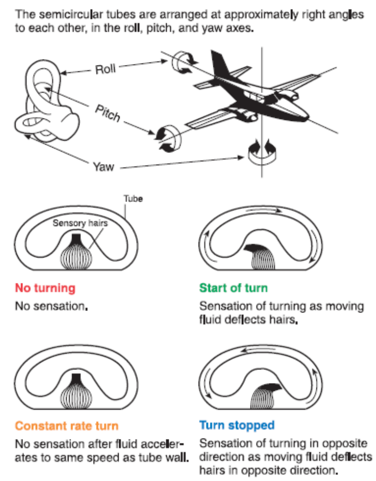
- ii. These risks can be prevented through thorough preflight planning and weather briefings
  - a. A few days prior to the planned flight check the expected weather
    - Monitor the weather reports in the days leading up to the planned flight
  - b. The day before the flight analyze the aviation weather products
  - c. The day of the flight reexamine the aviation weather products and get a weather brief
  - d. If the weather is not at least VFR do not go
    - Apply your own weather minimums based on experience, proficiency, comfort level, and safety
- iii. In the case unexpected weather puts you and the aircraft in a situation that is less than VFR use all capabilities available to safely exit the conditions, for example:
  - a. Flight Instruments – transition from visual references to instrument references. Trust the instruments to avoid spatial disorientation
    - Use the autopilot, if available, in order to further decrease the risk of spatial disorientation
  - b. ATC
    - Inform ATC of the conditions and request assistance in finding VMC conditions
  - c. GPS
    - The moving map display can be a great tool to maintain situational awareness
    - If satellite weather is available, use it to your advantage

B. Spatial Disorientation

- i. Explanation
  - a. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point, disorientation is the lack of orientation
  - b. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
  - c. The body uses three systems to ascertain orientation and movement in space
    - Visual: The eye, by far the largest source of information
    - Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
    - Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
  - d. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving
- ii. Relation to flight
  - a. Flying can result in conflicting information being sent to the brain, leading to disorientation
  - b. Visual System (eyes)
    - Flight in VMC
      - a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
    - Flight in IMC
      - a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
  - c. Vestibular System (ears)
    - The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
    - Two major parts: Semicircular Canals and Otolith Organs
    - Semicircular Canals
      - a Explanation

1. Detect angular acceleration
2. Three tubes at right angles to each other
    a. One on each of the three axes; pitch, roll, and yaw
3. Each canal is filled with a fluid
4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves

b How they work: In a Turn

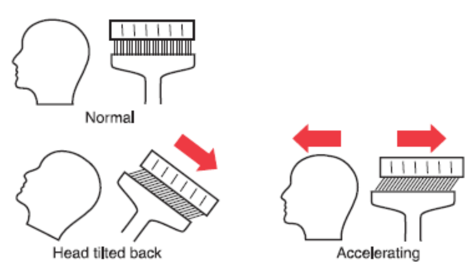


1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
    a. Glass of water illustration: wall is moving but water is not
2. The ear only detects turns of a short duration
    a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
    b. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)
        i. Glass of water illustration: water matches the speed of the glass
    c. When the turning stops, the ear canal stops moving but the fluid does not
        i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight
3. This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.

- Otolith Organs

a Explanation

1. Detect linear acceleration/gravity
2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift



b Acceleration

1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

d. Postural System (nerves)

- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity

- Acceleration will be felt as the pilot is pushed back into the seat
- False Sensations
    a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
        1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
    b Turbulence can create motions that confuse the brain
    c Fatigue or illness can exacerbate these sensations

iii. The Leans
   a. As mentioned above, when the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning. If the turn is entered too slowly to stimulate the motion sensing system and abrupt correction back to straight-and-level flight, the correction can create the illusion of banking in the opposite direction

iv. Countering the sensations
   a. Prevention is usually the best remedy for spatial disorientation
      - Unless a pilot has many hours of training in instrument flight, flights should be avoided in reduced visibility or at night when the horizon is not visible
   b. Trust the Instruments
      - A pilot can reduce susceptibility to disorienting illusions through training and awareness and learning to rely totally on flight instruments
          a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments
   c. Use the Autopilot
      - The autopilot can be an excellent tool in combatting a loss of situational awareness
   d. Ask for help
      - Confess the problem and request help
          a If you have another pilot in the aircraft confess that you're disoriented and transfer the controls
              1. Don't tell them what you're experiencing (it may cause them to see/feel the same thing). Simply tell them you're disoriented and transfer them the controls

C. Loss of Control
   i. In the case of instrument flying, especially with very little experience, it is easy to become spatially disoriented and/or end up in an unusual attitude
   ii. Trust the Instruments
      a. The body, eyes, and mind can be tricked without visual references. Trust the instruments and use the basic instrument maneuvers to maintain control
         - Establish, trim, crosscheck, adjust
   iii. Autopilot
      a. Use the autopilot to help reduce the chance of disorientation and a loss of control

D. Fatigue
   i. General
      a. Effects of Fatigue
         - Degradation of attention and concentration
         - Impaired coordination
         - Decreased ability to communicate
         - These factors seriously influence the ability to make effective decisions

        a Fatigue is frequently associated with pilot error
   b. Causes of Fatigue
      - Sleep Loss
      - Exercise, physical work
      - Factors such as stress and prolonged performance of cognitive work result in mental fatigue
   c. Fatigue can increase susceptibility to, and exacerbate spatial disorientation

ii. Types of Fatigue (Acute and Chronic)
   a. Acute
      - Short term and is a normal occurrence in everyday living. The kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep
      - Rest after exertion and 8 hours of sleep ordinarily cures this condition
      - A special type of acute fatigue is skill fatigue. This type of fatigue has two main effects on performance
         a Timing Disruption: appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integral activity
         b Disruption of the perceptual field: concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements
      - Causes of Acute Fatigue
         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 and adequate rest and sleep
            1. A well-balanced diet prevents the body from needing to consume its own tissue as an energy source
            2. Adequate rest maintains the body's store of vital energy
      - If suffering from acute fatigue, stay on the ground
         a If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects
         b Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day
   b. Chronic
      - Extends over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible
         a Continuous high stress levels produce chronic fatigue and it is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician
      - Symptoms
         a Weakness
         b Tiredness
         c Palpitations of the heart
         d Breathlessness
         e Headaches

- f Irritability
c. Pilots who suspect they are suffering from chronic fatigue should consult a physician

E. Stress
   i. The 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
      a. Physical stress (noise or vibration)
      b. Physiological stress (fatigue)
      c. Psychological stress (difficult work or personal situations)
   iv. Categories of Stress
      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. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
      b. Causes
         - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
      c. Pilots experiencing this level of stress are not safe and should not fly

F. Emergency Off Airport Landings
   i. Preflight Planning
      a. Off airport landings in instrument conditions can be very stressful
      b. Preflight planning, and being aware of the terrain, roads, airports, etc. can be of great assistance in a case like this
         - The pilot, if familiar with the area can navigate toward known flat areas or lines of communication (primarily roads) to increase the chance of being seen
   ii. ATC
      a. Communicate with ATC, advise them of the situation, inform them where you are, and where you're planning to go. Keep them updated as you progress.
      b. ATC can direct other aircraft or search and rescue to your location
   iii. Navigating in Instrument Conditions
      a. Without visual reference to the ground and potential landing spots navigating to a safe off airport landing area can be very difficult. Use any means available, examples include:
         - ATC may be able to provide vectors
         - GPS may indicate areas of low terrain or road
         - Sectional/terminal map. If the pilot is aware of his or her last known location and approximate heading may be able to point the aircraft in the direction of a safe landing area

2. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."

B. What actually constitutes an emergency can vary based on the situation
    i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination
C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
    i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.
D. Hesitation/Fear of Declaring
    i. For whatever reason, there is often a hesitation to declare an emergency
        a. In some circumstances, pilots can feel that by declaring an emergency means they failed
    ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
        a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate
            - Err on the side of caution
    iii. No one knows you have an emergency until you tell them
        a. ATC can't do anything to help you if they don't know there's a problem
        b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
        c. It gives you additional help
    iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
        a. Do not risk lives because you don't want to declare an emergency
            - Your pride has no place in a real or potential emergency situation
    v. Do not ever declare an emergency simply for priority
    vi. AvWeb: Declaring an Emergency and what happens next

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
    i. Operation Lights On
        a. A voluntary FAA safety program to enhance the see and avoid concept
        b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
    ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
            - If they are different categories:
                a A balloon has the right of way over any other category
                b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
                c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
                d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
        c. Approaching Head-on
            - Each pilot shall alter course to the right

d. Overtaking
   - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
   - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
     - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
     - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
   - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
   - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
   - This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
   - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield

a. Study sectionals and terminal area charts

b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
   - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
      b. Become familiar with any obstacles on the approach and departure path
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing
   iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
      a. Ensure proper clearance between the aircraft and obstacle
         - If unsure of clearance, stop until you're sure it is safe to pass
   v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. During spins, whether being practiced as a maneuver or in a real-world situation, the pilot's attention should be focused on the tasks at hand
      a. Flying takes precedence
         - Aviate, Navigate, Communicate
         - In the case of a real-life spin recovery, it is essential the pilot safely recover the aircraft
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin
   iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
      a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important in preventing stalls and spins. A loss of situational awareness can lead to a stall, spin, mishap, or incursion on the ground or in the air
   i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   ii. Maintain situational awareness
      a. If it is disoriented, admit it. If there's another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
   i. Attention needs to be divided between the various required tasks
      a. No one responsibility should take your full attention full more than a short period
         - Continually move between tasks to ensure everything is being taken care of
         - By effectively dividing attention, the pilot can deter the chance of a stall and spin
      b. Safety is your number one priority
         - Aviate, Navigate, Communicate
   ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
      a. Checklists are extremely helpful in properly managing tasks
   iii. Recognize when you are getting behind the aircraft, 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
   iv. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Transition to the descent pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
2. Demonstrate descents at a constant airspeed to specific altitudes in straight flight and turns.
3. Level off at the assigned altitude and maintain altitude ±200 feet, heading ±20° and airspeed ±10 knots.

VIII.D. Turns to Headings

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Flight Instruments Sensitivity, Limitations, and Potential Errors in Unusual Attitudes**
    - A. Attitude Indicator
        - i. Spillable Indicators
            - a. Do not depend on the attitude indicator during an unusual attitude if it is the spillable type, because its upset limits may have been exceeded or it may have become inoperative due to mechanical malfunction
        - ii. Nonspillable Indicators
            - a. If operating properly, errors up to 5 degrees of pitch and bank may result and indications are very difficult to interpret in extreme attitudes
    - B. Heading Indicator
        - i. Verify the heading indicator against the magnetic compass
            - a. This can be difficult in an unusual attitude since the compass may be swinging somewhat wildly. Wait for it to settle to ensure the heading indicator is accurate and has not precessed
    - C. Be aware of any limitations, errors, etc. associated with your specific flight instruments
2. **Flight Instrument Correlation (Pitch/Bank Instruments)**
    - A. Pitch Instruments (Constant Airspeed, Straight Climb)
        - i. The Instruments
            - a. Altimeter
            - b. Attitude Indicator
            - c. Vertical Speed Indicator (VSI)
        - ii. Procedure for Basic Instrument Maneuvers
            - a. Establish
                - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, a turn to a heading at a constant airspeed
                - Pitch Instruments: Set the attitude indicator at the desired pitch attitude
            - b. Trim
                - Trim the pitch control pressure for hands off flight
            - c. Crosscheck
                - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
                    - a The altimeter should indicate level
                    - b The VSI should indicate a zero rate of climb
                    - c The airspeed should be constant
                        1. Increasing airspeed can be a sign of a descent (with no other changes in power, configuration, etc.). Decreasing airspeed is a sign of a climb
            - d. Adjust
                - Make adjustments corresponding to the amount of change desired
                - 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
  e. Repeat the steps. After making an adjustment, trim the aircraft, crosscheck the instruments, and readjust if necessary…

B. Bank Instruments (Constant Heading/Straight Flight)
  i. The Instruments
    a. Heading Indicator
    b. Attitude Indicator
    c. Turn Coordinator
    d. Magnetic Compass
  ii. Procedure for Basic Instrument Maneuvers
    a. Establish
      - Establish the pitch, bank, and power settings necessary for the desired phase of flight. In this case, a turn to a heading at a constant airspeed
      - Bank Instruments: Set the attitude indicator for the desired angle of bank
    b. Trim
      - Trim the pitch control pressure for hands off flight
      - Rarely do general aviation aircraft have bank trim
    c. Crosscheck
      - Verify the aircraft is performing as desired using the altimeter and vertical speed indicator
        a The heading indicator should indicate a turn in the desired direction
        b The magnetic compass should also indicate a turn
        c The turn coordinator should indicate a turn and show coordinated flight
    d. Adjust
      - If the airplane is banking in one direction or the other, the bank should be readjusted to put the wings level on the attitude indicator
      - 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
      - It's important not to correct heading errors solely by yawing or rolling the airplane
        a Maintain a coordinated flight condition with coordinated aileron and rudder
        b Uncoordinated flight creates drag, slowing the aircraft since the fuselage is put into the relative wind

C. Pitch, Bank, and Power Settings for Constant Airspeed Climbs

Pitch + Power = Desired Performance
Wings Banked/Nose Slightly High + Cruise Power = Turn to Heading

Pitch		Bank	
A/I	Nose Slightly High	A/I	Wings Banked
Alt	Constant	DG	Turning to Heading
VSI	0	Compass	Turning to Heading
A/S	Constant Cruise AS	T/C	Banked/Coordinated

  i. Prior to entering, determine which direction the turn should be made and the angle of bank required

a. Use an angle of bank equal to the number of degrees to turn, not to exceed 30°

ii. Establish – coordinated aileron and rudder pressure to establish the desired bank angle on the attitude indicator

  a. If standard rate, use the turn coordinator to check

  b. Adjust pitch as necessary (increase) to maintain level flight

    - Add power as necessary to compensate for the additional induced drag

iii. Trim – Trim the airplane

iv. Crosscheck

v. Adjust – Correct any performance errors as necessary and go through the process again

vi. Rolling Out

  a. Apply coordinated rudder and aileron pressure to level the wings on the attitude indicator

    - Depending on the amount of turn, rollout about 10° before the desired heading

      a Or use ½ the bank angle or less for small turns

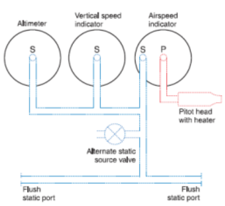
  b. Adjust the pitch to maintain level flight

    - Lower the nose and reduce power as necessary to return to straight and level flight at the same airspeed

3. Flight Instrument Function and Operation

A. Pitot-Static System (Altimeter, Vertical Speed Indicator, Airspeed Indicator)

i. 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

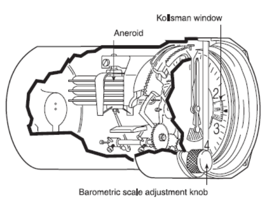
    - Ram air pressure used to measure airspeed

  d. The Pitot Tube connects to the airspeed indicator; the Static Port connects to all 3 instruments

ii. 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'

      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

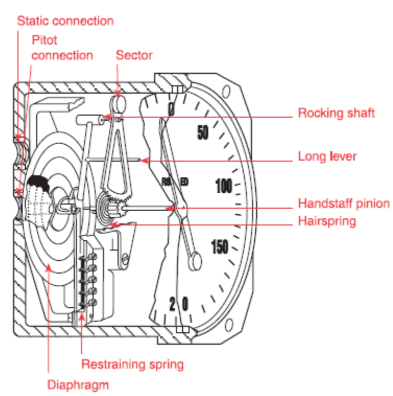
      b If air is colder than standard, it is denser, and pressure levels are closer together

        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. If the pilot does not change the altimeter settings, the altimeter will indicate lower
            2. 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, lowering true alt
        b The opposite applies from Low pressure to High pressure
    - REMEMBER: From hot to cold, or from high to low, look out below!

iii. 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 instrument 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

iv. 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 (the difference between pitot and static pressure)
  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 or static decreases, the diaphragm expands and vice versa
        a A rocking shaft and set of gears drives the AS needle

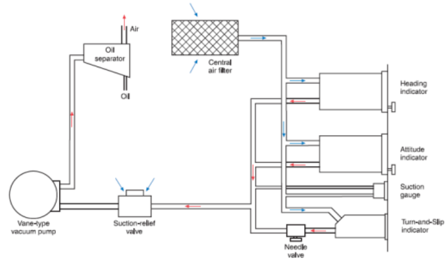


B. Gyroscopic System (Attitude & Heading Indicators, Turn Coordinator)

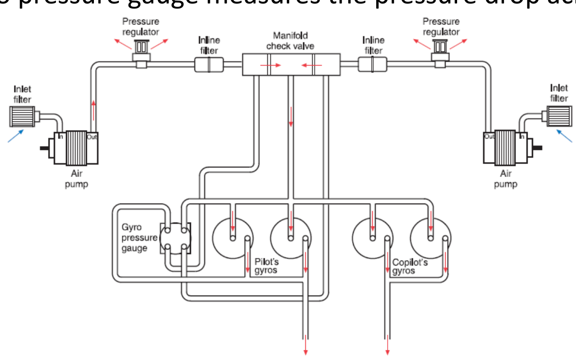
i. How it Works
  a. The 2 characteristics of gyroscopes: Rigidity and Precession
    - Rigidity: Characteristic that prevents its axis or rotation tilting as the Earth rotates
    - Precession: Characteristic that causes an applied force to be felt 90^{o} from that point in the direction of rotation
  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 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 180º turn
         c Some attitude indicators can tumble (lose their rigidity) if the aircraft pitch/bank attitude reaches a certain point. Beyond this point the attitude indicator may be unreliable

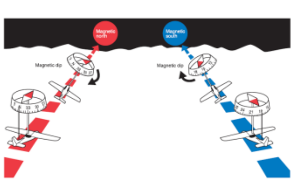
iii. Heading Indicator
   a. The gyro is mounted in a double gimbal axis in such a way that its spin axis is horizontal
      - Senses rotation about the vertical axis of the airplane
   b. Must be set to the appropriate heading by referring to a magnetic compass
      - Rigidity causes them to maintain 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
      - Precession can cause errors over time

iv. Turn Indicators
   a. Rate instruments operate on the principle of precession
   b. Turn-and-Slip Indicator
      - A small gyro mounted in a single gimbal
         a Gyro spin axis is parallel to the lateral axis; the gimbal axis is parallel to the longitudinal
      - Yawing, or rotating about the vertical axis, produces a force in the horizontal plane
         a This, due to precession, causes the gyro and its gimbal to rotate about the gimbal axis
      - Inclinometer
         a A black glass ball sealed inside a curved glass tube that is partially filled with a liquid
         b When straight and level, there is no inertia acting on the ball and it remains centered
         c In a turn with too steep a bank angle, gravity exceeds inertia and the ball rolls inward
         d In a turn with too shallow of bank, inertia exceeds gravity and the ball rolls outward
         e Only indicates the relationship between the angle of bank and the rate of yaw
   c. Turn Coordinator
      - Similar to the Turn and Slip Indicator, but its gimbal frame is angled upward about 30º from the longitudinal axis of the airplane
         a This allows it to sense both roll and yaw (not just yaw like the T&S Indicator)

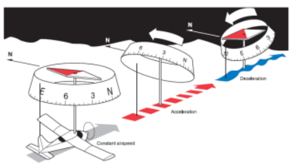
- The inclinometer is the same, and called a coordination ball
    - a Shows the relationship between the bank angle and rate of yaw
        1. Skidding when the ball rolls outside the turn
        2. Slipping when the ball rolls inside the turn

C. Magnetic Compass

- i. Operation
    - a. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid
    - b. A card is wrapped around the float and visible from the outside with a lubber line
        - Lubber Line: The reference line used in a magnetic compass or heading indicator
    - c. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup
        - The buoyancy of the float takes most of the weight off the pivot
        - The jewel and pivot type mounting allows the float to rotate and tilt up to approximately 18°
    - d. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line
        - The pilot sees the card from its backside
            - a The reason for this is the card remains stationary and the housing/pilot turn around it
- ii. Errors
    - a. Variation
        - Caused by the difference in the locations of the magnetic and geographic north pole
        - The north magnetic pole is not collocated with the geographic north pole
            - a The difference between true and magnetic directions
        - Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
        - Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation
    - b. Deviation
        - Caused by local magnetic fields within the aircraft; different on each heading
        - The magnets in a compass align with any magnetic field
            - a Local magnets caused by electrical currents will conflict with the Earth's field
        - Deviation varies by heading and is shown on a compass correction card
    - c. Finding the Compass Course
        - True Course ± Variation = Magnetic Course ± Deviation = Compass Course
        - Remember: East is Least, West is Best
            - a Subtract variation from true course, Add variation to true course
    - d. Dip Errors
        - What's Going On
            - a The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
                1. At both poles, the lines are perpendicular to the surface
                2. Over the equator, the lines are parallel to the surface
            - b The magnets align with these fields and near the poles they dip, tilt, the float/card
            - c The float is balanced with a small dip compensating weight, so it stays relatively level
        - Northerly Turning Error
            - a Caused by the pull of the vertical component of the Earth's magnetic field
            - b When flying on a heading of N, a turn to the E results in:
                1. The aircraft banking to the right and the compass card tilting to the right
                2. Then, the vertical component pulls the N seeking end of the compass to the right
                    - a. The float rotates, causing the card to rotate toward the W (opposite the turn)



        c The same happens when turning to the W; the float rotates to the E (opposite)
        d Remember: When starting a turn from a N heading, the compass lags behind the turn
        e When flying on a heading of S, a turn to the E results in:
            1. The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)
        f When turning to the W, the same happens; the float rotates to the W (same direction)
        g Remember: When starting a turn from a S heading, the compass leads the turn
        h Remember: UNOS - Undershoot North, Overshoot South
    - Acceleration Error



        a The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end
        b If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N
        c If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S
        d When flying on a heading of W, the same things happen
        e Remember: ANDS – Accelerate → North, Decelerate → South

e. Oscillation Error
    - Oscillation is a combination of all the other errors
        a It results in the compass card swinging back and forth around the heading being flown
    - When setting the HI to the MC, use the average indication

4. Proper Instrument Cross-check Techniques

A. What is Cross-checking?
    i. The continuous and logical observation of instruments for attitude and performance information

B. Techniques
    i. Using Analog Instrumentation (6-pack)
        a. Selected Radial Cross-Check
            - A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
            - With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
            - The maneuver being performed determines which instruments to look at in the pattern
        b. Inverted-V Cross-Check
            - The pilot scans from the attitude indicator down to the turn coordinator, up to the attitude indicator, down to the VSI, and back up to the attitude indicator
        c. Rectangular Cross-Check
            - The pilot scans across the top three instruments (airspeed indicator, attitude indicator, and altimeter) and then drops down to scan the bottom three instruments (VSI, heading indicator, and turn coordinator)
            - This scan follows a rectangular path; clockwise or counterclockwise is a personal choice
    ii. Using an Electronic Flight Display
        a. Selected Radial Cross-Check
            - A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
            - With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
            - The maneuver being performed determines which instruments to look at in the pattern

- The radial scan pattern works well for scanning the PFD
  - a The close proximity of the instrument tape displays necessitates very little eye movement in order to focus on the desired instrument
- Performing the Scan
  - a Start in the center, on the attitude indicator. Note the pitch attitude and then transition up to the slip/skid indicator and roll pointer to ensure the desired bank is set. Return to the attitude indicator. Scan left to the airspeed tape, verify it is as desired and return to the center of the display (attitude indicator). Scan to the right and verify the desired altitude is being maintained. Once verified, return to the center of the display, then transition down to the heading indicator to verify the desired heading. Once confirmed, return to the center of the display
  - b It is also important to include the engine indications in the scan
    1. Individualized scan methods may require adjustment if engine indications are presented on a separate MFD
  - c Another critical component to include in the scan is the moving map display located on the MFD

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

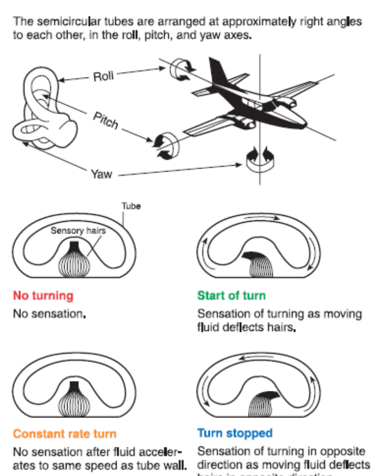
1. Instrument Flying Hazards to Include Failure to Maintain VFR, Spatial Disorientation, Loss of Control, Fatigue, Stress, and Emergency Off Airport Landings

A. Failure to Maintain VFR
   i. Risks include disorientation, loss of control, getting lost, icing conditions, excessive stress, midair collision, and more
   ii. These risks can be prevented through thorough preflight planning and weather briefings
      a. A few days prior to the planned flight check the expected weather
         - Monitor the weather reports in the days leading up to the planned flight
      b. The day before the flight analyze the aviation weather products
      c. The day of the flight reexamine the aviation weather products and get a weather brief
      d. If the weather is not at least VFR do not go
         - Apply your own weather minimums based on experience, proficiency, comfort level, and safety
   iii. In the case unexpected weather puts you and the aircraft in a situation that is less than VFR use all capabilities available to safely exit the conditions, for example:
      a. Flight Instruments – transition from visual references to instrument references. Trust the instruments to avoid spatial disorientation
         - Use the autopilot, if available, in order to further decrease the risk of spatial disorientation
      b. ATC
         - Inform ATC of the conditions and request assistance in finding VMC conditions
      c. GPS
         - The moving map display can be a great tool to maintain situational awareness
         - If satellite weather is available, use it to your advantage

B. Spatial Disorientation
   i. Explanation

a. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point, disorientation is the lack of orientation
b. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
c. The body uses three systems to ascertain orientation and movement in space
    - Visual: The eye, by far the largest source of information
    - Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
    - Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
d. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving

ii. Relation to flight
a. Flying can result in conflicting information being sent to the brain, leading to disorientation
b. Visual System (eyes)
    - Flight in VMC
        a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
    - Flight in IMC
        a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
c. Vestibular System (ears)
    - The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
    - Two major parts: Semicircular Canals and Otolith Organs
    - Semicircular Canals
        a Explanation
            1. Detect angular acceleration
            2. Three tubes at right angles to each other
                a. One on each of the three axes; pitch, roll, and yaw
            3. Each canal is filled with a fluid
            4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves
        b How they work: In a Turn
            1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
                a. Glass of water illustration: wall is moving but water is not
            2. The ear only detects turns of a short duration
                a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
                b. At the same speed, the hairs detect no relative movement and the sensation of



turning ceases (it feels like straight and level flight)

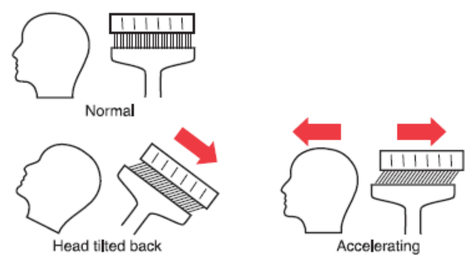
            i. Glass of water illustration: water matches the speed of the glass

        c. When the turning stops, the ear canal stops moving but the fluid does not

            i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight

    3. This can be demonstrated: Establish a 30º bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.

- Otolith Organs
    - a Explanation
        1. Detect linear acceleration/gravity
        2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
        3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift



    - b Acceleration
        1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

d. Postural System (nerves)
- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- Acceleration will be felt as the pilot is pushed back into the seat
- False Sensations
    - a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
        1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity
    - b Turbulence can create motions that confuse the brain
    - c Fatigue or illness can exacerbate these sensations

iii. The Leans

a. As mentioned above, when the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning. If the turn is entered too slowly to stimulate the motion sensing system and abrupt correction back to straight-and-level flight, the correction can create the illusion of banking in the opposite direction

iv. Countering the sensations

a. Prevention is usually the best remedy for spatial disorientation
- Unless a pilot has many hours of training in instrument flight, flights should be avoided in reduced visibility or at night when the horizon is not visible

b. Trust the Instruments

- A pilot can reduce susceptibility to disorienting illusions through training and awareness and learning to rely totally on flight instruments
  - a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments

c. Use the Autopilot

- The autopilot can be an excellent tool in combatting a loss of situational awareness

d. Ask for help

- Confess the problem and request help
  - a If you have another pilot in the aircraft confess that you're disoriented and transfer the controls
    1. Don't tell them what you're experiencing (it may cause them to see/feel the same thing). Simply tell them you're disoriented and transfer them the controls

C. Loss of Control

i. In the case of instrument flying, especially with very little experience, it is easy to become spatially disoriented and/or end up in an unusual attitude

ii. Trust the Instruments

a. The body, eyes, and mind can be tricked without visual references. Trust the instruments and use the basic instrument maneuvers to maintain control

- Establish, trim, crosscheck, adjust

iii. Autopilot

a. Use the autopilot to help reduce the chance of disorientation and a loss of control

D. Fatigue

i. General

a. Effects of Fatigue

- Degradation of attention and concentration
- Impaired coordination
- Decreased ability to communicate
- These factors seriously influence the ability to make effective decisions
  - a Fatigue is frequently associated with pilot error

b. Causes of Fatigue

- Sleep Loss
- Exercise, physical work
- Factors such as stress and prolonged performance of cognitive work result in mental fatigue

c. Fatigue can increase susceptibility to, and exacerbate spatial disorientation

ii. Types of Fatigue (Acute and Chronic)

a. Acute

- Short term and is a normal occurrence in everyday living. The kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep
- Rest after exertion and 8 hours of sleep ordinarily cures this condition
- A special type of acute fatigue is skill fatigue. This type of fatigue has two main effects on performance
  - a Timing Disruption: appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integral activity

b Disruption of the perceptual field: concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements

- Causes of Acute Fatigue
  - 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 and adequate rest and sleep
    1. A well-balanced diet prevents the body from needing to consume its own tissue as an energy source
    2. Adequate rest maintains the body's store of vital energy
- If suffering from acute fatigue, stay on the ground
  - a If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects
  - b Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day

b. Chronic

- Extends over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible
  - a Continuous high stress levels produce chronic fatigue and it is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician
- Symptoms
  - a Weakness
  - b Tiredness
  - c Palpitations of the heart
  - d Breathlessness
  - e Headaches
  - f Irritability

c. Pilots who suspect they are suffering from chronic fatigue should consult a physician

E. Stress

i. The 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

a. Physical stress (noise or vibration)

b. Physiological stress (fatigue)

c. Psychological stress (difficult work or personal situations)

iv. Categories of Stress

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. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
   b. Causes
      - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
   c. Pilots experiencing this level of stress are not safe and should not fly

F. Emergency Off Airport Landings
   i. Preflight Planning
      a. Off airport landings in instrument conditions can be very stressful
      b. Preflight planning, and being aware of the terrain, roads, airports, etc. can be of great assistance in a case like this
         - The pilot, if familiar with the area can navigate toward known flat areas or lines of communication (primarily roads) to increase the chance of being seen
   ii. ATC
      a. Communicate with ATC, advise them of the situation, inform them where you are, and where you're planning to go. Keep them updated as you progress.
      b. ATC can direct other aircraft or search and rescue to your location
   iii. Navigating in Instrument Conditions
      a. Without visual reference to the ground and potential landing spots navigating to a safe off airport landing area can be very difficult. Use any means available, examples include:
         - ATC may be able to provide vectors
         - GPS may indicate areas of low terrain or road
         - Sectional/terminal map. If the pilot is aware of his or her last known location and approximate heading may be able to point the aircraft in the direction of a safe landing area

2. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."

B. What actually constitutes an emergency can vary based on the situation
   i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination

C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
   i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.

D. Hesitation/Fear of Declaring
   i. For whatever reason, there is often a hesitation to declare an emergency
      a. In some circumstances, pilots can feel that by declaring an emergency means they failed
   ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
      a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate
         - Err on the side of caution
   iii. No one knows you have an emergency until you tell them
      a. ATC can't do anything to help you if they don't know there's a problem

b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
c. It gives you additional help

iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
a. Do not risk lives because you don't want to declare an emergency
- Your pride has no place in a real or potential emergency situation

v. Do not ever declare an emergency simply for priority

vi. [AvWeb: Declaring an Emergency] and what happens next

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance

i. Operation Lights On
a. A voluntary FAA safety program to enhance the see and avoid concept
b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
  a A balloon has the right of way over any other category
  b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
  c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
  d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
- Each pilot shall alter course to the right

d. Overtaking
- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
  a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
  a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:

- 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
  a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
  b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
    - This is also more applicable to cruise, but can be used while the pattern, if necessary
  c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
  a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
  i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  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
      - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
  i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages
  ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see

            - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted
        c. Be extremely vigilant on takeoff and landing
    iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
        a. Ensure proper clearance between the aircraft and obstacle
            - If unsure of clearance, stop until you’re sure it is safe to pass
    v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
    i. During spins, whether being practiced as a maneuver or in a real-world situation, the pilot’s attention should be focused on the tasks at hand
        a. Flying takes precedence
            - Aviate, Navigate, Communicate
            - In the case of a real-life spin recovery, it is essential the pilot safely recover the aircraft
    ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
        a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin
    iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
        a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important in preventing stalls and spins. A loss of situational awareness can lead to a stall, spin, mishap, or incursion on the ground or in the air
    i. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    ii. Maintain situational awareness
        a. If it is disoriented, admit it. If there’s another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem

C. Task Management
    i. Attention needs to be divided between the various required tasks
        a. No one responsibility should take your full attention full more than a short period
            - Continually move between tasks to ensure everything is being taken care of
            - By effectively dividing attention, the pilot can deter the chance of a stall and spin
        b. Safety is your number one priority
            - Aviate, Navigate, Communicate
    ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        a. Checklists are extremely helpful in properly managing tasks
    iii. Recognize when you are getting behind the aircraft, 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

iv. Don’t give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Demonstrate turns to headings, maintain altitude ±200 feet and maintain a standard rate turn and rolls out on the assigned heading ±10°; maintain airspeed ±10 knots.

VIII.E. Recovery from Unusual Flight Attitudes

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Flight Instruments Sensitivity, Limitations, and Potential Errors in Unusual Attitudes**
   - A. Attitude Indicator
     - i. Spillable Indicators
       - a. Do not depend on the attitude indicator during an unusual attitude if it is the spillable type, because its upset limits may have been exceeded or it may have become inoperative due to mechanical malfunction
     - ii. Nonspillable Indicators
       - a. If operating properly, errors up to 5 degrees of pitch and bank may result and indications are very difficult to interpret in extreme attitudes
   - B. Heading Indicator
     - i. Verify the heading indicator against the magnetic compass
       - a. This can be difficult in an unusual attitude since the compass may be swinging somewhat wildly. Wait for it to settle to ensure the heading indicator is accurate and has not precessed
   - C. Be aware of any limitations, errors, etc. associated with your specific flight instruments
2. **Flight Instrument Correlation (Pitch/Bank Instruments)**
   - A. The flight instruments will be set to return to straight and level flight. There are two procedures to recover from an unusual attitude:
     - i. Nose High Recovery
       - a. Recognized by a nose high pitch attitude, decreasing airspeed, increasing altitude, climb on the vertical speed indicator, and a high pitch on the attitude indicator
         - If you have a spillable attitude indicator, do not rely on it during an unusual attitude
       - b. Recovery is meant to prevent a stall
         - Increase power as necessary based on deceleration
         - Lower the nose to prevent a stall
         - Roll the wings level (coordinated aileron and rudder)
         - The corrections are made almost simultaneously, but in the sequence above
     - ii. Nose Low Recovery
       - a. Recognized by a nose low pitch attitude, increasing airspeed, decreasing altitude, descent on the vertical speed indicator, and a high pitch on the attitude indicator
         - If you have a spillable attitude indicator, do not rely on it during an unusual attitude
       - b. Recovery is meant to prevent over G-ing the aircraft
         - Reduce power to prevent excessive speed and loss of altitude
         - Roll the wings level (coordinated aileron and rudder)
         - Raise the nose to establish level flight
         - The corrections are made almost simultaneously, but in the sequence above
   - B. Recovery Flight Controls
     - i. Pitch Instruments (Constant Altitude/Level Flight)
       - a. Crosscheck:
         - The altimeter

        - a To check that the altitude is no longer increasing and is slowing or stopping
    - The attitude indicator
        - a To show the position of the nose in relation to the horizon and that it approximates level flight (if it has not spilled)
    - VSI
        - a To check that the ascent has been stopped and the aircraft is level
    - Airspeed Indicator
        - a To check that the airspeed is no longer decreasing and is stable or accelerating to a cruise speed

ii. Corrections (Adjust)
  a. Recover as discussed above
    - Establish a pitch attitude for level flight, trim the control forces, crosscheck that the desired performance (level flight) is obtained and make the necessary adjustments
  b. 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
  c. Elevators are the control
    - Forward or back elevator pressure is used to control the pitch attitude
        - a Increasing pitch attitude (back pressure) raises the nose in relation to the horizon
        - b Decreasing pitch attitude (forward pressure) lowers the nose in relation to the horizon
  d. Note the relationship between control pressure and the airplane's change in attitude

iii. Bank Instruments (Constant Heading/Straight Flight)
  a. Crosscheck:
    - The heading indicator
        - a To determine that any turn has been stopped and the aircraft if flying straight
    - The attitude indicator
        - a To ensure the wings are now level
    - Turn Coordinator
        - a To ensure coordination and that the aircraft is not unintentionally in a turn
    - Magnetic Compass
        - a Again, to ensure the desired heading is maintained and the heading indicator is correct
  b. Corrections (Adjust)
    - 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
        - a Remember, during a nose high unusual attitude recovery, add max power, lower the nose, then level the wings with coordinated rudder/aileron (avoid the stall)
        - b During a nose low, level the wings, and then increase back pressure (avoid over G-ing the aircraft)
    - Ailerons and rudder are the control
        - a Right aileron pressure (turns right) results in the left wing raising, and right wing lowering
            1. Combine right aileron with right rudder to maintain coordination
        - b Left aileron pressure (turns left) results in the right wing raising, and the left wing lowering
            1. Combine right aileron with right rudder to maintain coordination
        - c Remember, that with the addition of power, right rudder will be necessary to maintain heading and coordination
    - Note the relationship between control pressure and the airplane's change in attitude

- It’s important not to correct heading errors solely by yawing or rolling the airplane
    - a Maintain a coordinated flight condition
    - b Uncoordinated flight slows the aircraft since the fuselage is put into the relative wind and risks a spin in the case of a stall (especially since the pitch attitude is high and the airspeed is low)

C. Pitch, Bank, and Power Settings for Establishing Level Flight after an Unusual Attitude

Pitch + Power = Desired Performance
Nose on Horizon + Cruise Power = Straight and Level

Pitch		Bank	
A/I	On Horizon	A/I	Wings Level
Alt	Constant	DG/Hdg Ind	Constant
VSI	0	Compass	Constant
Airspeed	Return to Cruise	T/C	Level/Coordinated

i. Establish – Use the recovery procedure
   a. Nose High: Increase power, lower the nose toward the horizon, then level the wings (rudder/aileron)
   b. Nose Low: Decrease power, level the wings (rudder/aileron), then raise the nose toward the horizon

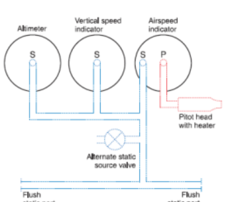
ii. Trim - Trim to relieve the control pressures

iii. Crosscheck
   a. Verify the pitch attitude returns the aircraft to level flight (avoid using the attitude indicator if it is spillable), and airspeed is returning to cruise speed (readjust the power as necessary)

iv. Adjust - Correct any performance errors as necessary and re-trim the airplane, then crosscheck again

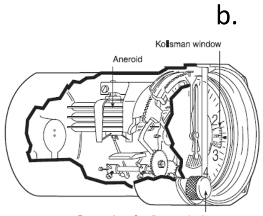
C. **Flight Instrument Function and Operation**

D. Pitot-Static System (Altimeter, Vertical Speed Indicator, Airspeed Indicator)



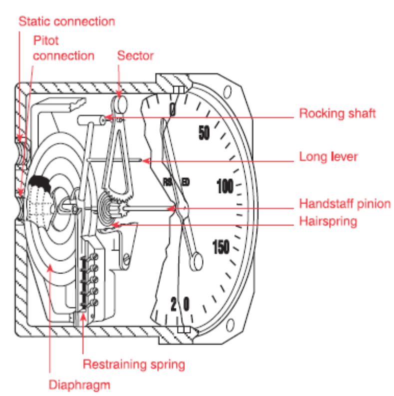
i. How it Works
   a. Flight instruments depend on accurate sampling of the ambient atmospheric pressure
      - This is used to determine the height and speed of movement of the aircraft through the air
   b. Static Pressure (still air pressure) is measured at a flush port where air is not disturbed
      - 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

ii. 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’
    - 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. If the pilot does not change the altimeter settings, the altimeter will indicate lower
                2. 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, lowering true alt
            b The opposite applies from Low pressure to High pressure
        - REMEMBER: From hot to cold, or from high to low, look out below!
iii. 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 instrument 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
iv. 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 (the difference between pitot and static pressure)

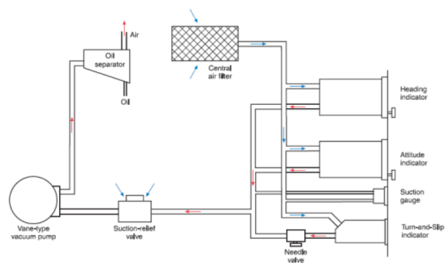


    b. Principle of Operation
        - Consists of a thin, corrugated phosphor bronze aneroid, or diaphragm, receiving its pressure from the pitot tube
        - The instrument is sealed and connected to the static port(s)
        - As pitot pressure increases or static decreases, the diaphragm expands and vice versa
            a A rocking shaft and set of gears drives the AS needle

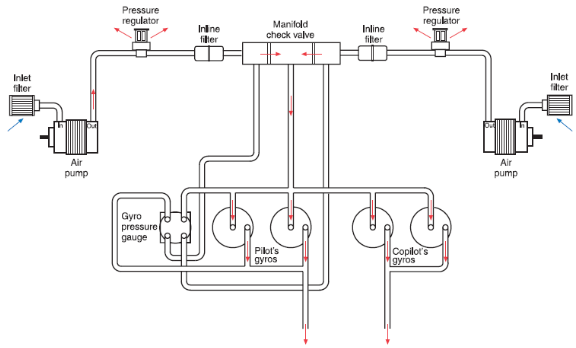
E. Gyroscopic System (Attitude & Heading Indicators, Turn Coordinator)
i. How it Works
    a. The 2 characteristics of gyroscopes: Rigidity and Precession
        - Rigidity: Characteristic that prevents its axis or rotation tilting as the Earth rotates
        - Precession: Characteristic that causes an applied force to be felt 90º 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 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
         c Some attitude indicators can tumble (lose their rigidity) if the aircraft pitch/bank attitude reaches a certain point. Beyond this point the attitude indicator may be unreliable

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
      - Precession can cause errors over time

iv. Turn Indicators
   a. Rate instruments operate on the principle of precession
   b. Turn-and-Slip Indicator
      - A small gyro mounted in a single gimbal
         a Gyro spin axis is parallel to the lateral axis; the gimbal axis is parallel to the longitudinal
      - Yawing, or rotating about the vertical axis, produces a force in the horizontal plane
         a This, due to precession, causes the gyro and its gimbal to rotate about the gimbal axis

- Inclinometer
    - a A black glass ball sealed inside a curved glass tube that is partially filled with a liquid
    - b When straight and level, there is no inertia acting on the ball and it remains centered
    - c In a turn with too steep a bank angle, gravity exceeds inertia and the ball rolls inward
    - d In a turn with too shallow of bank, inertia exceeds gravity and the ball rolls outward
    - e Only indicates the relationship between the angle of bank and the rate of yaw

c. Turn Coordinator

- Similar to the Turn and Slip Indicator, but its gimbal frame is angled upward about 30° from the longitudinal axis of the airplane
    - a This allows it to sense both roll and yaw (not just yaw like the T&S Indicator)
- The inclinometer is the same, and called a coordination ball
    - a Shows the relationship between the bank angle and rate of yaw
        1. Skidding when the ball rolls outside the turn
        2. Slipping when the ball rolls inside the turn

F. Magnetic Compass

i. Operation

a. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid

b. A card is wrapped around the float and visible from the outside with a lubber line

- Lubber Line: The reference line used in a magnetic compass or heading indicator

c. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup

- The buoyancy of the float takes most of the weight off the pivot
- The jewel and pivot type mounting allows the float to rotate and tilt up to approximately 18°

d. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line

- The pilot sees the card from its backside
    - a The reason for this is the card remains stationary and the housing/pilot turn around it

ii. Errors

a. Variation

- Caused by the difference in the locations of the magnetic and geographic north pole
- The north magnetic pole is not collocated with the geographic north pole
    - a The difference between true and magnetic directions
- Isogonic Lines: Lines drawn across aeronautical charts connecting points have the same magnetic variation
- Agonic Line: An irregular imaginary line across the surface of the Earth along which the magnetic and geographic poles are aligned and along which there is no magnetic variation

b. Deviation

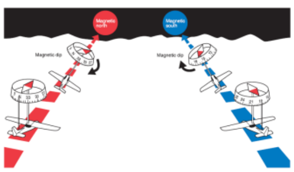
- Caused by local magnetic fields within the aircraft; different on each heading
- The magnets in a compass align with any magnetic field
    - a Local magnets caused by electrical currents will conflict with the Earth's field
- Deviation varies by heading and is shown on a compass correction card

c. Finding the Compass Course

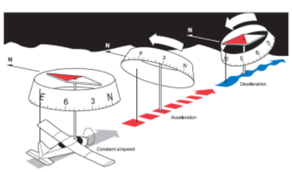
- True Course ± Variation = Magnetic Course ± Deviation = Compass Course
- Remember: East is Least, West is Best
    - a Subtract variation from true course, Add variation to true course

d. Dip Errors

- What's Going On
  - a The lines of magnetic flux are considered to leave the Earth at the magnetic N pole and enter at the magnetic S pole
    1. At both poles, the lines are perpendicular to the surface
    2. Over the equator, the lines are parallel to the surface
  - b The magnets align with these fields and near the poles they dip, tilt, the float/card
  - c The float is balanced with a small dip compensating weight, so it stays relatively level
- Northerly Turning Error
  - a Caused by the pull of the vertical component of the Earth's magnetic field
  - b When flying on a heading of N, a turn to the E results in:



    1. The aircraft banking to the right and the compass card tilting to the right
    2. Then, the vertical component pulls the N seeking end of the compass to the right
       a. The float rotates, causing the card to rotate toward the W (opposite the turn)
  - c The same happens when turning to the W; the float rotates to the E (opposite)
  - d Remember: When starting a turn from a N heading, the compass lags behind the turn
  - e When flying on a heading of S, a turn to the E results in:
    1. The Earth's field pulling on the end of the magnet that rotates the card toward the E (same as the turn)
  - f When turning to the W, the same happens; the float rotates to the W (same direction)
  - g Remember: When starting a turn from a S heading, the compass leads the turn
  - h Remember: UNOS - Undershoot North, Overshoot South
- Acceleration Error



  - a The dip-correction weight causes the end of the float and card marked N (S seeking end) to be heavier than the opposite end
  - b If the aircraft accelerates on a heading of E, the inertia of the weight holds its end of the float back, and the card rotates toward the N
  - c If the aircraft decelerates on a heading of E, inertia causes the weight to move ahead and the card rotates to the S
  - d When flying on a heading of W, the same things happen
  - e Remember: ANDS – Accelerate → North, Decelerate → South

e. Oscillation Error

- Oscillation is a combination of all the other errors
  - a It results in the compass card swinging back and forth around the heading being flown
- When setting the HI to the MC, use the average indication

3. Proper Instrument Cross-check Techniques

A. What is Cross-checking?

i. The continuous and logical observation of instruments for attitude and performance information

B. Techniques

i. Using Analog Instrumentation (6-pack)

a. Selected Radial Cross-Check

- A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
- With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
- The maneuver being performed determines which instruments to look at in the pattern

b. Inverted-V Cross-Check

- The pilot scans from the attitude indicator down to the turn coordinator, up to the attitude indicator, down to the VSI, and back up to the attitude indicator

c. Rectangular Cross-Check
   - The pilot scans across the top three instruments (airspeed indicator, attitude indicator, and altimeter) and then drops down to scan the bottom three instruments (VSI, heading indicator, and turn coordinator)
   - This scan follows a rectangular path; clockwise or counterclockwise is a personal choice

ii. Using an Electronic Flight Display
   a. Selected Radial Cross-Check
      - A pilot spends 80 to 90 percent of flight time looking at the attitude indicator, taking only quick glances at the other flight instruments
      - With this method, the pilot's eyes never travel directly between the flight instruments but move by way of the attitude indicator
      - The maneuver being performed determines which instruments to look at in the pattern
      - The radial scan pattern works well for scanning the PFD
        a The close proximity of the instrument tape displays necessitates very little eye movement in order to focus on the desired instrument
      - Performing the Scan
        a Start in the center, on the attitude indicator. Note the pitch attitude and then transition up to the slip/skid indicator and roll pointer to ensure the desired bank is set. Return to the attitude indicator. Scan left to the airspeed tape, verify it is as desired and return to the center of the display (attitude indicator). Scan to the right and verify the desired altitude is being maintained. Once verified, return to the center of the display, then transition down to the heading indicator to verify the desired heading. Once confirmed, return to the center of the display
        b It is also important to include the engine indications in the scan
           1. Individualized scan methods may require adjustment if engine indications are presented on a separate MFD
        c Another critical component to include in the scan is the moving map display located on the MFD

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

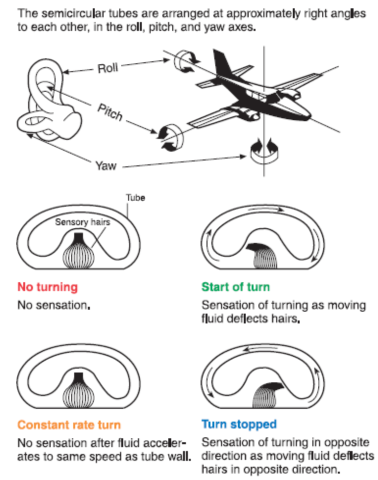
1. Instrument Flying Hazards to Include Failure to Maintain VFR, Spatial Disorientation, Loss of Control, Fatigue, Stress, and Emergency Off Airport Landings

A. Failure to Maintain VFR
   i. Risks include disorientation, loss of control, getting lost, icing conditions, excessive stress, midair collision, and more
   ii. These risks can be prevented through thorough preflight planning and weather briefings
      a. A few days prior to the planned flight check the expected weather
         - Monitor the weather reports in the days leading up to the planned flight
      b. The day before the flight analyze the aviation weather products
      c. The day of the flight reexamine the aviation weather products and get a weather brief
      d. If the weather is not at least VFR do not go

        - Apply your own weather minimums based on experience, proficiency, comfort level, and safety
   iii. In the case unexpected weather puts you and the aircraft in a situation that is less than VFR use all capabilities available to safely exit the conditions, for example:
      a. Flight Instruments – transition from visual references to instrument references. Trust the instruments to avoid spatial disorientation
         - Use the autopilot, if available, in order to further decrease the risk of spatial disorientation
      b. ATC
         - Inform ATC of the conditions and request assistance in finding VMC conditions
      c. GPS
         - The moving map display can be a great tool to maintain situational awareness
         - If satellite weather is available, use it to your advantage

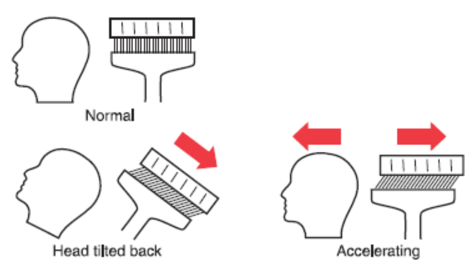
B. Spatial Disorientation
   i. Explanation
      a. Orientation is the awareness of the position of the aircraft and of oneself in relation to a specific reference point, disorientation is the lack of orientation
      b. Spatial Disorientation refers to the lack of orientation with regard to the position, attitude, or movement of the airplane in space
      c. The body uses three systems to ascertain orientation and movement in space
         - Visual: The eye, by far the largest source of information
         - Postural: The sensation of position, movement, and tension perceived through nerves, muscles, and tendons
         - Vestibular System: A very sensitive motion sensing system located in the inner ears. It reports head position, orientation, and movement in three-dimensional space
      d. All of this info comes together in the brain, and most of the time, the three streams of information agree, giving a clear idea of where and how the body is moving
   ii. Relation to flight
      a. Flying can result in conflicting information being sent to the brain, leading to disorientation
      b. Visual System (eyes)
         - Flight in VMC
            a The eyes are the major orientation system and usually prevail over false sensations from the other systems when outside references are available
         - Flight in IMC
            a When visual cues are taken away, the eyes cannot correct for the false sensations, and a pilot can become disoriented
      c. Vestibular System (ears)
         - The vestibular system in the inner ear allows the pilot to sense movement and determine orientation in the surrounding environment
         - Two major parts: Semicircular Canals and Otolith Organs
         - Semicircular Canals
            a Explanation
               1. Detect angular acceleration
               2. Three tubes at right angles to each other
                  a. One on each of the three axes; pitch, roll, and yaw
               3. Each canal is filled with a fluid
               4. In the center of the canal is the cupola, a gelatinous structure that rests upon sensory hairs located at the end of the vestibular nerves

- b How they work: In a Turn
  1. When the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning
     a. Glass of water illustration: wall is moving but water is not



  2. The ear only detects turns of a short duration
     a. After approximately 20 seconds, the fluid accelerates and moves at the same speed as the ear canal
     b. At the same speed, the hairs detect no relative movement and the sensation of turning ceases (it feels like straight and level flight)
        i. Glass of water illustration: water matches the speed of the glass
     c. When the turning stops, the ear canal stops moving but the fluid does not
        i. This moves the sensory hairs in the opposite direction, creating the sensation of a turn in the opposite direction even though the aircraft is flying straight
  3. This can be demonstrated: Establish a 30° bank turn, tell the student to close their eyes and let you know when the aircraft is flying straight. Maintain the turn, after about 20 seconds the student should feel as though the aircraft is out of the turn, have them open their eyes. 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.

- Otolith Organs
  - a Explanation
    1. Detect linear acceleration/gravity
    2. A gelatinous membrane containing chalk like crystals covers the sensory hairs
    3. When you tilt your head, the weight of the crystals causes the membrane to shift due to gravity and the sensory hairs detect the shift



  - b Acceleration
    1. Forward acceleration gives the illusion of the head tilting backward and deceleration gives the illusion of the head tilting forward

d. Postural System (nerves)

- Nerves in the body's skin, muscles, and joints constantly send signals to the brain, which signals the body's relation to gravity
- Acceleration will be felt as the pilot is pushed back into the seat
- False Sensations
  - a Forces created in turns can lead to false sensations of the direction of gravity, and may give the pilot a false sense of which way is up
    1. The brain has no way of differentiating between the forces of a turn (coordinated or uncoordinated) and the force of gravity

        b Turbulence can create motions that confuse the brain
        c Fatigue or illness can exacerbate these sensations
    iii. The Leans
        a. As mentioned above, when the ear canal is moved in its plane (a turn is started), the relative motion of the fluid moves the cupola, which stimulates the sensory hairs to provide the sensation of turning. If the turn is entered too slowly to stimulate the motion sensing system and abrupt correction back to straight-and-level flight, the correction can create the illusion of banking in the opposite direction
    iv. Countering the sensations
        a. Prevention is usually the best remedy for spatial disorientation
            - Unless a pilot has many hours of training in instrument flight, flights should be avoided in reduced visibility or at night when the horizon is not visible
        b. Trust the Instruments
            - A pilot can reduce susceptibility to disorienting illusions through training and awareness and learning to rely totally on flight instruments
                a Recognize the problem, disregard the false sensations, and rely totally on the flight instruments
        c. Use the Autopilot
            - The autopilot can be an excellent tool in combatting a loss of situational awareness
        d. Ask for help
            - Confess the problem and request help
                a If you have another pilot in the aircraft confess that you're disoriented and transfer the controls
                    1. Don't tell them what you're experiencing (it may cause them to see/feel the same thing). Simply tell them you're disoriented and transfer them the controls

C. Loss of Control
    i. In the case of instrument flying, especially with very little experience, it is easy to become spatially disoriented and/or end up in an unusual attitude
    ii. Trust the Instruments
        a. The body, eyes, and mind can be tricked without visual references. Trust the instruments and use the basic instrument maneuvers to maintain control
            - Establish, trim, crosscheck, adjust
    iii. Autopilot
        a. Use the autopilot to help reduce the chance of disorientation and a loss of control

D. Fatigue
    i. General
        a. Effects of Fatigue
            - Degradation of attention and concentration
            - Impaired coordination
            - Decreased ability to communicate
            - These factors seriously influence the ability to make effective decisions
                a Fatigue is frequently associated with pilot error
        b. Causes of Fatigue
            - Sleep Loss
            - Exercise, physical work
            - Factors such as stress and prolonged performance of cognitive work result in mental fatigue
        c. Fatigue can increase susceptibility to, and exacerbate spatial disorientation

ii. Types of Fatigue (Acute and Chronic)
    a. Acute
        - Short term and is a normal occurrence in everyday living. The kind of tiredness people feel after a period of strenuous effort, excitement, or lack of sleep
        - Rest after exertion and 8 hours of sleep ordinarily cures this condition
        - A special type of acute fatigue is skill fatigue. This type of fatigue has two main effects on performance
            a Timing Disruption: appearing to perform a task as usual, but the timing of each component is slightly off. This makes the pattern of the operation less smooth because the pilot performs each component as though it were separate, instead of part of an integral activity
            b Disruption of the perceptual field: concentrating attention upon movements or objects in the center of vision and neglecting those in the periphery. This is accompanied by loss of accuracy and smoothness in control movements
        - Causes of Acute Fatigue
            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 and adequate rest and sleep
                1. A well-balanced diet prevents the body from needing to consume its own tissue as an energy source
                2. Adequate rest maintains the body's store of vital energy
        - If suffering from acute fatigue, stay on the ground
            a If fatigue occurs in the flight deck, no amount of training or experience can overcome the detrimental effects
            b Avoid flying without a full night's rest, after working excessive hours, or after an especially exhausting or stressful day
    b. Chronic
        - Extends over a long period of time, usually has psychological roots, although an underlying disease is sometimes responsible
            a Continuous high stress levels produce chronic fatigue and it is not relieved by proper diet and adequate rest and sleep and usually requires treatment by a physician
        - Symptoms
            a Weakness
            b Tiredness
            c Palpitations of the heart
            d Breathlessness
            e Headaches
            f Irritability
    c. Pilots who suspect they are suffering from chronic fatigue should consult a physician

E. Stress
    i. The 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
        a. Physical stress (noise or vibration)
        b. Physiological stress (fatigue)
        c. Psychological stress (difficult work or personal situations)
    iv. Categories of Stress
        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. A level of stress that presents an intolerable burden, exceeds the ability of an individual to cope, and causes individual performance to fall sharply
        b. Causes
            - Unrelenting psychological pressures such as loneliness, financial worries and relationship or work problems
        c. Pilots experiencing this level of stress are not safe and should not fly
F. Emergency Off Airport Landings
    i. Preflight Planning
        a. Off airport landings in instrument conditions can be very stressful
        b. Preflight planning, and being aware of the terrain, roads, airports, etc. can be of great assistance in a case like this
            - The pilot, if familiar with the area can navigate toward known flat areas or lines of communication (primarily roads) to increase the chance of being seen
    ii. ATC
        a. Communicate with ATC, advise them of the situation, inform them where you are, and where you’re planning to go. Keep them updated as you progress.
        b. ATC can direct other aircraft or search and rescue to your location
    iii. Navigating in Instrument Conditions
        a. Without visual reference to the ground and potential landing spots navigating to a safe off airport landing area can be very difficult. Use any means available, examples include:
            - ATC may be able to provide vectors
            - GPS may indicate areas of low terrain or road
            - Sectional/terminal map. If the pilot is aware of his or her last known location and approximate heading may be able to point the aircraft in the direction of a safe landing area

2. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."
B. What actually constitutes an emergency can vary based on the situation
    i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination
C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency

    i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.

D. Hesitation/Fear of Declaring
    i. For whatever reason, there is often a hesitation to declare an emergency
        a. In some circumstances, pilots can feel that by declaring an emergency means they failed
    ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
        a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate
            - Err on the side of caution
    iii. No one knows you have an emergency until you tell them
        a. ATC can't do anything to help you if they don't know there's a problem
        b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
        c. It gives you additional help
    iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
        a. Do not risk lives because you don't want to declare an emergency
            - Your pride has no place in a real or potential emergency situation
    v. Do not ever declare an emergency simply for priority
    vi. AvWeb: Declaring an Emergency and what happens next

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
    i. Operation Lights On
        a. A voluntary FAA safety program to enhance the see and avoid concept
        b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
    ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
            - If they are different categories:
                a A balloon has the right of way over any other category
                b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
                c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
                d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
        c. Approaching Head-on
            - Each pilot shall alter course to the right
        d. Overtaking
            - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
  - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
    - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
  - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
    - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
  - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
  - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
  - This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
  - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield

a. Study sectionals and terminal area charts

b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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
  - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
b. Become familiar with any obstacles on the approach and departure path
c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
d. At and below 200’ AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers
a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
- Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure

iii. Overhead Wires
a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
b. These wires and lines may or may not be lighted
c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
a. Ensure proper clearance between the aircraft and obstacle
- If unsure of clearance, stop until you’re sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
i. Distractions are a major cause of unusual attitudes
a. Flying takes precedence
- Aviate, Navigate, Communicate
- In the case of a real-life unusual attitude, it is essential the pilot safely recover the aircraft

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
a. Remove the distraction prior to it becoming enough of a hazard to induce a stall or spin

iii. Distractions can lead to various dangerous situations (unusual attitudes, slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.)
a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Situational awareness is extremely important in preventing an unusual attitude.
i. Maintain situational awareness
a. If it is disoriented, admit it. If there’s another pilot, let him or her take over while you catch up. If not, get the aircraft in a safe position (if landing, go around; accelerate out of slow flight if necessary) and then solve the problem
b. Trust the instruments – be aware of, recognize and ignore the false sensations that can lead to unusual attitudes
- If disoriented, use the instruments (other than the attitude indicator if it is spillable) to recover from the unusual attitude

ii. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio

C. Task Management

i. Attention needs to be divided between the various required tasks
    a. No one responsibility should take your full attention full more than a short period
        - Continually move between tasks to ensure everything is being taken care of
        - By effectively dividing attention, the pilot can deter the chance of a stall and spin
    b. Safety is your number one priority
        - Aviate, Navigate, Communicate
ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks
iii. Recognize when you are getting behind the aircraft, 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
iv. Don't give up or overstress yourself. Take it one step at a time.

5. Failure to Interpret Flight Instruments

A. A failure to interpret flight instruments can lead to an unusual attitude, and in the case of an unusual attitude recovery, can result in incorrect procedures
  i. Causing an unusual Attitude
    a. Be very familiar with the flight instruments, their meaning and how to interpret them
    b. Unfamiliarity can lead to an unusual attitude
  ii. Unusual Attitude Recovery
    a. An improper recovery due to a failure to interpret the flight instruments can aggravate the situation
    b. Nose High
        - Improper recovery techniques can result in the aircraft stalling
    c. Nose Low
        - Improper recovery techniques can result in overstressing the airframe
    d. To prevent this, study and follow the procedures outlined above. Recognize the type of unusual attitude and apply the correct procedures
        - In the case your attitude indicator is spillable, do not use it to recognize or recover from the unusual attitude. Use the other instruments for the information required

6. Failure to Unload the Wings in Recovering from High G Situations

A. The nose low recovery is performed with the intention of stopping the aircraft descent and acceleration without over stressing the airframe (avoiding high G situations)
  i. By decreasing airspeed (or decreasing the rate of acceleration) and leveling the wings, the nose can be raised with considerably less stress than with the wings banked and the aircraft accelerating
    a. More bank = More G (or load) on the wings when transitioning to level flight
        - This is because a portion of the vertical lift is transferred to horizontal lift, meaning additional pitch is needed to compensate for the bank and return to level flight
        - Pulling the nose up with the aircraft banked can increase the stresses on the wings and damage the airframe
  ii. Avoid overstressing the airframe by following the recovery procedure and using smooth controlled inputs to return to level flight.

SKILLS

The applicant demonstrates the ability to:

1. Recognize unusual flight attitudes; perform the correct, coordinated, and smooth flight control application to resolve unusual pitch and bank attitudes while staying within the airplane's limitations and flight parameters.

VIII.F. Radio Communications, Navigation Systems/Facilities, and Radar Services

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Instrument Flying Handbook (FAA-H-8083-15), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25)

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Operating Communications Equipment to Include Identifying and Selecting Radio Frequencies, Requesting and Following ATC Instructions**
   - A. Equipment
     - i. Radio communication equipment will vary based on the aircraft
       - a. Usually at least one VHF radio is available
         - This can create issues when multiple frequencies need attention, for example while talking to ATC and needing to listen to the ATIS. Request to leave ATC momentarily to get ATC and check back in when done
       - b. Other aircraft may have multiple VHF radios, UHF radios, HF radios, satellite communications capability, etc.
     - ii. Identifying and Selecting Radio Frequencies
       - a. Identifying
         - ATC frequencies will be published along with airport information in the Chart Supplement or various apps (foreflight, etc.)
           - a Ensure you have the desired frequency
             - 1. In the case you cannot reach the intended controller, double check the frequency
         - Navigation Frequencies
           - a Nav frequencies can be found on sectionals and terminal charts
         - Stations can be identified by Morse code IDs or a voice stating the name and VOR
           - a If the navaid is out of service, the coded identification is removed and not transmitted. It should not be used for navigation.
           - b Glass displays, such as the G1000, will automatically identify the navaid and display the navaid identifier to confirm identification
             - 1. If the navaid isn't displayed, verify the frequency by Morse code. If Morse code is unavailable the navaid should not be used for navigation
       - b. Selecting a Frequency
         - This will vary based on the radio system(s) installed in the aircraft. Be familiar with the system installed in your aircraft and its operation
   - B. Requesting and Following ATC Instructions
     - i. Understanding is the single most important thought in pilot-controller communications
       - a. It is essential that pilots acknowledge each radio call with ATC with the appropriate aircraft call sign
       - b. Brevity is important, but when necessary, use whatever words will get your message across
         - Know what you're going to say before you say it
       - c. Good phraseology enhances safety and is the mark of a professional pilot
         - The Pilot/Controller Glossary (AIM) is very helpful in learning what certain words/phrases mean
     - ii. Radio Technique
       - a. LISTEN before you transmit

b. THINK before transmitting - Know what you want to say before you say it (write it down if needed)
c. After transmitting, wait a few seconds before calling again (The controller may be busy)
d. Be alert to the sound/lack of sounds in the receiver
    - Check your volume, frequency, and make sure the microphone isn't stuck on transmit
e. Be sure you are within the performance range of your equipment and the ground station equipment
    - Remember higher altitudes increase the range of VHF "line of sight" communications

iii. Radio calls can be broken down into:
a. Whom you are calling (Chicago Center)
b. Who you are (Diamond 4TS)
c. Where you are (10 miles South of _____)
d. What you want to do (Request flight following, or whatever you want)

iv. Improper procedure and phraseology for radio communications are common:
a. Think before you transmit and understand the controller may be busy
b. Tailor your calls to match the controller's workload
c. Use the Pilot/Controller glossary to ensure correct, succinct radio calls

v. FAR 91.123 - Compliance with ATC Clearances and Instructions
a. When an ATC clearance has been obtained, no PIC 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.
    - However, a pilot may cancel an IFR flight plan if the operation is being conducted in VFR weather conditions (except in Class A airspace)
    - When a pilot is uncertain of an ATC clearance, that pilot shall immediately request clarification from ATC.
b. 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.
c. Each pilot in command 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.
d. Each pilot in command who (though not deviating from a rule of this subpart) 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.
e. Unless otherwise authorized by ATC, no person operating an aircraft may operate that aircraft according to any clearance or instruction that has been issued to the pilot of another aircraft for radar air traffic control purposes.

2. Operating Navigation Equipment to Include Functions and Displays, and Following Bearings, Radials or Courses

A. Very High Frequency Omni-Directional Range (VOR)

i. Three types of VORS
a. VOR – The VOR by itself, provides magnetic bearing information to and from the station
b. VOR/DME – When DME (Distance Measuring Equipment) is also installed with the VOR
c. VORTAC – When military tactical air navigations (TACAN) equipment is installed with a VOR
    - DME is always an integral part of a VORTAC

ii. 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 distance the radials are projected depends on the power output of the transmitter

c. 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 considered to be excellent (within +/- 1°)

d. VOR ground stations transmit within a VHF frequency band of 108.0 – 117.95 MHz
- Because the equipment is VHF, the signals are subject to line-of-sight restrictions
    - a Therefore, range varies in direct proportion to the altitude of the receiving equipment

e. VORs are classed according to operational use in 3 classes with varying normal useful ranges:
- T (Terminal); L (Low Altitude); H (High 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

iii. VOR Checks

a. The best assurance of maintaining an accurate VOR receiver is periodic checks and calibrations
- Not a regulation for VFR flight

b. Checks (checkpoints are listed in the Chart Supplement)
- FAA VOR Test Facility (VOT)
- Certified Airborne Checkpoints
- Certified Ground Checkpoints located on airport surfaces
- Dual VOR check

c. Verifies the VOR radials received are aligned with the radials the station transmits

d. IFR tolerances required are +/- 4° for ground checks and +/- 6° for airborne checks

iv. Using the VOR

a. Identifying It
- Station can be identified by its Morse code ID or a voice stating the name and VOR
- If the VOR is out of service, the coded identification is removed and not transmitted
    - a It should not be used for navigation
- VOR receivers have an alarm flag to indicate when signal strength is inadequate
    - a The plane is either too far or too low and is out of the line-of-sight of the signal

b. There are 2 required components for VOR radio navigation
- The ground transmitter and the receiver
    - a The transmitter is at a specific position on the ground and transmits on an assigned frequency
    - b Airplane equipment includes the receiver with a tuning device and a VOR instrument
        1. The navigation instrument consists of:
            - **a.** An OBS (Omni Bearing Selector), referred to as the course selector
            - **b.** A CDI (Course Deviation Indicator) Needle

c. A To/From Indicator

- Course selector is an azimuth dial that is rotated to select a radial/determine the radial on
  - a In addition, the magnetic course TO or FROM the station can be determine
- When the OBS is rotated, the CDI moves showing the radial relative to the airplane
- If centered, the CDI will show the radial (MC FROM)/its reciprocal (MC TO)
- The CDI will also move to the right or left if the airplane is away from the radial selected

c. TO and FROM

- By centering the needle, either the course "FROM" or "TO" the station will be indicated
  - a If the flag displays "TO," the course on the course selector must be flown to the station
  - b If "FROM" is displayed and the course followed, the plane flies away from the station

v. VOR Tips

a. Positively identify the station by its code or voice identification
b. Remember, VOR signals are line-of-sight
c. When navigating TO, determine the inbound radial and use it (Don't reset radial, correct drift)
d. When flying TO a station always fly the selected course with a TO indication
e. When flying FROM a station always fly the selected course with a FROM indication

B. Distance Measuring Equipment (DME)

i. Function

a. When with a VOR, DME can determine position, including bearing and distance TO/FROM
b. Used for determining the distance from a ground DME transmitter
c. The info can be used to determine position or fly a track at a constant distance from a station

ii. How it Works

a. The aircraft DME transmits interrogating RF pulses which a DME antenna on the ground receives
b. The signal triggers ground receiver equipment to respond back to the interrogating aircraft
c. The airborne DME measures the elapsed time between the sent signal and the reply signal
   - The time measurement is converted into NMs from the station
d. Some receivers provide GS by monitoring the rate of change of position to the station
e. DME operates on UHF frequencies between 962 MHz and 1213 MHz

iii. Components

a. Ground Equipment
   - VOR/DME, VORTAC, ILS/DME, and LOC/DME provide DME course and distance info
b. Airborne Equipment
   - An antenna and a receiver
c. Pilot Controllable Features
   - Channel (frequency) Selector: To select the proper channel/frequency
   - On/Off/Volume: Can be used to identify the DME (Morse code plays 1x for every 3-4x VOR)
   - Mode Switch: Cycles between Distance, GS and time to station
   - Altitude: Some correct for slant range error

iv. Errors

a. DME signals are line of sight
b. Slant Range Distance
   - The mileage readout is the straight-line distance from the aircraft to the ground facility
   - Differs from the distance from the station to the point on the ground beneath the aircraft
   - This error is the smallest at low altitudes and long range
     - a It is greatest when over the ground facility, when it will display altitude above
     - b Negligible if 1 mile or more away from the facility for each 1,000' above facility elevation

C. Instrument Landing System (ILS)

i. An electronic system that provides both horizontal and vertical guidance to a specific runway, used to execute a precision instrument approach procedure

ii. Ground Components

   a. Localizer: Provides horizontal guidance along the centerline of the runway
      - The portion of the ILS that gives left/right guidance info down the centerline of the instrument runway for final approach
      - Located on the extended centerline
      - Radiates a field pattern, which develops a course down the centerline toward the MM/OMs
         - a Also radiates a similar course along the runway centerline in the opposite direction
            1. These are the front and back courses, respectively
      - Provides course guidance between 108.1 and 111.95 MHz (odd tenths only)
         - a Guidance is given from 18 nm from the antenna up to 4,500' above antenna elevation
      - Localizer Course is very narrow, normally 5^o
         - a A full-scale deflection shows when 2.5^o to either side of the centerline
            1. With no more than ¼ scale deflection, the airplane will be aligned with the runway

   b. Glide Slope: Provides vertical guidance toward the runway touchdown point, usually a 3^o slope
      - Part of the ILS that projects a radio beam upward at an angle of approx. 3^o from the approach end of an instrument runway to provide vertical guidance for final approach
      - Equipment is housed in a building approx. 750-1250' down from the approach end of the runway, and 400-600' to one side of the centerline
      - The course projected is basically the same as a localizer on its side
         - a The projection angle is normally $2.5\text{-}3.5^o$ above the horizontal
            1. This intersects the MM at about 200'/OM at about 1,400' above runway elevation
      - Only radiates signal in the direction of the final approach on the front course
      - Normally a 1.4^o thick glide path (at 10 nm, this equals 1,500' and narrows to a few feet at TD)

   c. Marker Beacons: Provide range info along the approach path
      - A low powered transmitter that directs its signal upward in a small, fan shaped pattern. Used along the flightpath when approaching an airport for landing, marker beacons indicate, both aurally and visually, when the aircraft is directly over the facility
      - Two VHF marker beacons, Outer and Middle, are normally used in the ILS system
         - a A third beacon, Inner, is used where Category II ops are certified
      - The Outer Marker (OM)
         - a Located on the localizer front course 4 to 7 miles from the airport
         - b Indicates where, when at the appropriate alt, on the localizer one will intercept glide path
      - The Middle Marker (MM)
         - a Approx. 3,500' from the landing threshold on the centerline of the localizer front course
         - b It is at a position where the glide-slope centerline is about 200' above the landing threshold
      - The Inner Marker (IM)
         - a Located on the front course between the MM and the landing threshold
         - b Indicates the decision height on a Category II ILS approach
      - Compass Locator
         - a Low powered NDBs which are received and indicated by the ADF receiver
         - b When used in conjunction with an ILS front course, the compass locator facilities are collocated with the outer and/or MM facilities

d. Approach Lights: Assist in the transition from instrument to visual flight
    - Visual stage of the instrument approach
        a The landing is continued with reference to runway touchdown zone markers
    - Visual identification of the ALS must be instantaneous, so it's important to know the type
        a ALSF, SSALR, MALSR, REL, MALSF, ODALS, also VASIs

iii. Airborne Components: Include receivers for the:
a. Localizer
    - Typical VOR receiver is also a localizer receiver and functions the same way
b. Glide Slope
    - Glide slope is tuned automatically to the proper frequency when the localizer is tuned
    - Each localizer frequency is paired with a corresponding glide slope frequency
c. Marker Beacon
    - OM
        a Low-pitch tone
        b Continuous dashes at the rate of 2 per second
        c Purple/blue marker beacon light
    - MM
        a Intermediate tone
        b Alternate dots and dashes at a rate of 95 dot/dash combinations per minute
        c Amber marker beacon light
    - IM
        a High-pitched tone
        b Continuous dots at the rate of 6 per second
        c White marker beacon light
    - BCM (Back Course Marker)
        a High pitched tone
        b Two dots at a rate of 72 to 75 two dot combinations per minute
        c White marker beacon light
    - Sensitivity: can be selected as high or low
        a Low provides the sharpest indication of position and should be used on approach
d. ADF
e. DME
f. And the respective indicator instruments

iv. Other components (not specific components but may be incorporated for safety and utility)
a. Compass Locators: Provide transition from en route NAVAIDS to the ILS system
    - Assist in holding procedures, tracking the localizer course, identifying marker beacon sites, and providing a FAF for ADF approaches
b. DME collocated with Glide Slope Transmitter: Provides positive distance to touchdown info

v. Three Types
a. Category I: Provide for approach to a height above touchdown of not less than 200'
b. Category II: Provide for approach to a height above touchdown of not less than 100'
c. Category III: Provide lower minimums for approaches without a decision height minimum
    - II and III require special certification for the pilots, as well as ground/airborne equipment

vi. Errors
a. Reflection: Surface vehicles/aircraft below 5,000' AGL may disturb the signal
b. False Courses: GS facilities inherently produce additional courses at higher vertical angles
    - If the approach is made at the altitudes shown on the charts, they won't be encountered

D. Automatic Direction Finder (ADF)
   i. The NDB is a ground-based radio transmitter that transmits radio energy in all directions
      a. The ADF, when used with an NDB, determines the bearing from the aircraft to the station
   ii. The ADF needle points to the NDB ground station to determine the relative bearing
      a. Relative Bearing: The number of degrees measured clockwise between the heading of the aircraft and the direction from which the bearing is taken
   iii. Magnetic Heading + Relative Bearing = Magnetic Bearing
      a. Mary Had + Roast Beef= Marry Barfed
      b. Magnetic Heading: The direction an aircraft is pointed with respect to magnetic North
      c. Magnetic Bearing: The direction to or from a radio transmitting station measured relative to magnetic North
      d. NDB Components
         - The ground equipment, the NDB, which transmits between 190 to 535 KHz
         - The aircraft must be in operational range of the NDB
            a Depends on the strength of the station
      e. ADF Components
         - The airborne equipment; includes 2 antennas, a receiver, and the indicator instrument
         - Antenna
            a Sense Antenna: (Non-directional) Receives signals nearly equally from all directions
            b Loop Antenna: (Bi directional) Receives signals better from 2 directions
            c When put together in the ADF it can receive well in all directions but 1
               1. Therefore, resolving any directional ambiguity

         - Indicator Instrument
            a 3 kinds: Fixed card ADF, Movable Card ADF, or the RMI
            b Fixed Card ADF
               1. Always indicates 0 at the top and the needle indicates RB to the station
            c Movable Card ADF
               1. Rotates to allow the current heading to be at the top of the instrument
                  a. This allows the head of the needle to indicate the MB to the station
                  b. The tail indicates MB from the station
            d RMI
               1. Automatically rotates the azimuth card to represent aircraft heading
               2. Has 2 needles which can be used for nav info from either the ADF or VOR receivers
               3. When the ADF is driving the needle, the head indicates MB TO the station tuned
                  a. The tail is the MB FROM the station tuned
               4. With the VOR driving, the needle shows location radially with respect to the station
                  a. The needle points to the bearing TO the station
                  b. The tail points to the radial of the VOR the aircraft is currently on/crossing
      f. Using the NDB
         - Orientation
            a The ADF needle points TO the station, regardless of heading or position
               1. RB indicated thus is the angular relationship between heading and the station
                  a. Measured clockwise from the nose of the aircraft
            b Visualize the ADF dial in terms of the longitudinal axis
               1. When the needle points to 0°, the nose points directly to the station
               2. With the pointer on 210°, the station is 30° to the left of the tail
               3. With the pointed on 090°, the station is off the right wingtip

4. The RB itself does not indicate position
    a. The RB must be related to aircraft heading to determine direction TO/FROM

E. Global Position System (GPS)
    i. Satellite based navigation systems include
        a. GPS (Global Positioning System), WAAS (Wide Area Augmentation System), LAAS (Local…)
        b. The GPS system is composed of 3 major elements
            - The Space Segment
                a Composed of a constellation of 24 satellites approximately 11,000 NM above the earth
                    1. Arranged so at any time, 5 are in view to any receiver (4 are necessary for operation)
                    2. Each satellite orbits the Earth in approximately 12 hours
                    3. Equipped with highly stable atomic clocks and transmit a unique code/nav message
                b The satellites broadcast in the UHF range (so they are virtually unaffected by weather)
                    1. 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
            - The Control Segment
                a Consists of a master control station, 5 monitoring stations, and 3 ground antennas
                b The monitoring stations and ground antennas are distributed around the earth to allow continual monitoring and communications with satellites
                    1. Nav message updates are uplinked as satellites pass over the ground antennas
            - The User Segment
                a Consists of all components associated with the GPS receiver
                    1. Range from portable, hand-held receivers to permanently installed
                b The receiver utilizes the signals from the satellites to provide:
                    1. Positioning, velocity, and precise timing to the user
        c. Solving for Location
            - The receiver utilizes the signals of at least 4 of the best positioned satellites to yield a 3D fix
                a 3D - Latitude, longitude, and altitude
                b Using distance/position info from the satellite, the receiver calculates its location
        d. Navigating
            - VFR navigation with GPS can be as simple as selecting a destination and tracking the course
            - GPS Tracking
                a Course deviation is linear, there is no increase in sensitivity closer to waypoints
            - It can be very tempting to rely exclusively on GPS, but never rely on one means of navigation
        e. Receiver Autonomous Integrity Monitoring (RAIM)
            - RAIM is the GPS receiver's ability to verify the integrity (usability) of the signals received from the GPS constellation
                a Without RAIM capability, the pilot has no assurance of the accuracy of the GPS position
            - RAIM needs a minimum of 5 satellites in view, or 4 satellites and a barometric altimeter baro-aiding to detect an integrity anomaly
                a Some receivers have the ability to isolate and remove a corrupt signal if 6 satellites, (or 5 with baro-aiding) are in view
            - Generally, there are 2 types of RAIM messages
                a One indicates that there are not enough satellites in view to provide RAIM
                b Another indicates that the RAIM has detected a potential error that exceeds the limit required for the current phase of flight

- Aircraft using GPS navigation equipment under IFR must be equipped with an approved and operation alternate means of navigation appropriate to the route of flight, but active monitoring of the alternative navigation equipment is not required if the GPS receiver uses RAIM for integrity monitoring
  - a Active monitoring of navigation equipment is required when the RAIM capability of the GPS equipment is lost though
  - b In situations where the loss of RAIM capability is predicted to occur, the flight must rely on other approved equipment, delay departure, or cancel the flight

f. GPS Substitution

- GPS systems, certified for IFR en route and terminal operations, may be used as a substitute for ADF and DME receivers when conducting the following operations within the NAS:
  - a Determining the aircraft position over a DME fix
  - b Flying a DME arc
  - c Navigation TO/FROM an NDB/Compass Locator
  - d Determining the aircraft position over an NDB/compass locator
  - e Determining the aircraft position over a fix defined by an NDB/Compass Locator bearing crossing a VOR/LOC course
  - f Holding over an NDB/Compass Locator

ii. WAAS

a. Designed to improve the accuracy, integrity, and availability of GPS signals

- The integrity is improved through real-time monitoring of the satellites, the accuracy is improved by providing corrections to the satellites to reduce errors. As a result, performance improvement is sufficient to enable approach procedures with GPS/WAAS glidepaths

b. Approach Capabilities

- WAAS receivers support all basic GPS approach functions and provide additional capabilities with the key benefit to generate an electronic glidepath, independent of ground equipment or barometric aiding
  - a This eliminates several problems, such as cold temperature effects, incorrect altimeter setting, or lack of a local altimeter source, and allows approach procedures to be built without the cost of installing ground stations at each airport.
- A new class of approach procedures, which provide vertical guidance requirements for precision approaches, has been developed. These procedures are called Approach with Vertical Guidance (APV) and include approaches such as LNAV/VNAV procedures presently being flown

iii. LAAS

a. A ground-based augmentation system that uses a GPS-reference facility located on or in the vicinity of the airport being serviced

- This facility has a reference receiver that measures GPS satellite pseudo-range and timing and retransmits the signal.
- Aircraft landing at LAAS-equipped airports are able to conduct approaches to Category I level and above for properly equipped aircraft

3. Air Traffic Control Facilities and Services

A. Facilities

i. Clearance Delivery/Ground/Tower

a. These are the local airport frequencies

        b. Clearance Delivery provides clearances to IFR aircraft and often can coordinate VFR flight following
        c. Ground provides taxi clearance and directions
        d. Tower provides takeoff clearance and controls the airspace designated to the airport
    ii. TRACON
        a. Terminal Radar Approach Control (TRACON)
        b. "Approach" and "Departure" control for aircraft arriving and departing the local airport airspace
    iii. ARTCC
        a. Air Route Traffic Control Center
        b. "Center" provides enroute advisories and controls large portions of airspace across the US. They control the enroute phase of flight.
B. Services
    i. ATC facilities provide a variety of services to participating VFR aircraft on a workload permitting basis
        a. You must be able to communicate with ATC, be within radar coverage and be radar identified
        b. Services provided include:
            - VFR radar traffic advisory service (Flight Following) and safety alerts
            - Vectoring (when requested)
            - Terminal Radar Programs (TRSA) – To separate all participating VFR aircraft and IFR traffic
            - Radar assistance to lost aircraft
            - Class C services include separation between IFR/VFR and sequencing of VFR traffic to the airport
            - Class B services include separation based on IFR, VFR and/or weight and sequencing VFR arrivals

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Seek Assistance or Declare an Emergency in a Deteriorating Situation

A. FAR 91.3, which describes the pilot in command's authority, is relatively succinct: "In an emergency requiring immediate action, the pilot in command may deviate from any rule... to the extent required to meet the emergency."
B. What actually constitutes an emergency can vary based on the situation
    i. EX: 15 minutes of fuel on final approach vs 15 min of fuel 30 miles from your destination
C. The PIC is the final authority as to what constitutes an emergency and will be provided priority and assistance in the case of an emergency
    i. Examples of emergencies: Low fuel, mechanical issues (engine failure, landing gear or flap malfunctions) or impending mechanical issues (such as low oil pressure, or a rough running engine – both likely will lead to engine failure), lost, icing, VFR pilot in IMC conditions, etc.
D. Hesitation/Fear of Declaring
    i. For whatever reason, there is often a hesitation to declare an emergency
        a. In some circumstances, pilots can feel that by declaring an emergency means they failed
    ii. Declaring an emergency is done for the safety of yourself, your passengers, and the surrounding aircraft
        a. If you are experiencing an emergency, declare an emergency – don't wait, don't hesitate

        - Err on the side of caution
    iii. No one knows you have an emergency until you tell them
        a. ATC can't do anything to help you if they don't know there's a problem
        b. Declaring the emergency not only informs them of the issue, but allows them to do something about it
        c. It gives you additional help
    iv. If you're unsure as to whether an emergency should be declared or not, it's likely a good idea to declare the emergency, get on the ground and reconsider the decision from the safety of the ground
        a. Do not risk lives because you don't want to declare an emergency
            - Your pride has no place in a real or potential emergency situation
    v. Do not ever declare an emergency simply for priority
    vi. AvWeb: Declaring an Emergency and what happens next

2. Failure to Utilize all Available Resources

A. Resource Utilization
    i. To make the most informed decisions, the pilot must be aware of the resources both inside and outside the cockpit

B. Internal Resources
    i. POH is essential for accurate flight planning and resolving equipment malfunctions
    ii. Checklists verify instruments and systems are checked, set, and operating properly and ensure the proper procedures are performed in the case of an emergency
    iii. Equipment - A thorough understanding of the equipment is necessary to fully utilize all resources
        a. Program any info ahead of time (GPS, radio frequencies, fixes, etc.)
        b. If you do not understand equipment or rely on certain equipment (like the GPS) excessively it can be unsafe
            - EX: If the GPS fails and you do not have a good understanding of VOR navigation, how will you maintain situation awareness and return home or divert to another field?
    iv. Automation – use the automation to reduce your workload and increase situational awareness
        a. Always monitor the automation to ensure it's doing what is desired
    v. Passengers can look for traffic, and provide helpful information (strange sound/scent, checklist help)
    vi. Charts, other pilots, and your own ingenuity, knowledge and skill are also excellent resources

C. External Resources
    i. ATC, maintenance technicians, and flight service personnel
        a. ATC/Flight Service specialists can decrease work with traffic advisories, vectors and emergency assistance
            - May be able to access maintenance personnel, or other assistance in an emergency
    ii. FSS can provide weather and airport conditions
    iii. Other aircraft can provide PIREPs and relay radio communications
        a. Occasionally other aircraft may be able to hear your transmission, but not the controller
            - In this case, other aircraft can relay messages between you and the controller
    iv. ASOS/AWOS can also provide weather conditions in flight
    v. In some instances, a phone call may be an option

SKILLS

The applicant demonstrates the ability to:

1. Maintain aircraft control while selecting proper communications frequencies, identifying the appropriate facility, and managing navigation equipment.
2. Comply with ATC instructions.
3. Maintain altitude ±200 feet, heading ±20° and airspeed ±10 knots.

EMERGENCY OPERATIONS

IX.A. Emergency Descent

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Situations that Require an Emergency Descent

- A. Depressurization
  - i. Be aware of the symptoms of hypoxia as its onset can be subtle and slow
    - a. Don emergency oxygen
  - ii. Follow the manufacturer's checklist
  - iii. Understand the time of useful consciousness/hypoxia and its symptoms and get on emergency oxygen immediately
    - a. The cabin altitude needs to be returned to livable oxygen levels; an emergency descent is required
- B. Engine Fire
  - i. An engine fire is usually caused by a failure that allows a flammable substance such as fuel, oil or hydraulic fluid to come in contact with a hot surface
    - a. Engine fires can be indicated by smoke and/or flames coming from the engine cowling. They can also be indicated by discoloration, bubbling, and/or melting of the engine cowling skin in cases where flames and/or smoke is not visible to the pilot
    - b. By the time the pilot is aware of an engine fire, it is usually well developed
  - ii. Follow the manufacturer's checklist
    - a. You will likely shutdown the engine and prepare for an emergency landing
    - b. An emergency descent may assist in extinguishing the flames
      - If the engine is shut down and the problem handled, it may be beneficial to stop the emergency descent to increase the glide distance
  - iii. Engine fires which appear to have been extinguished have been known to rekindle with changes in airflow pattern and airspeed
    - a. The pilot must be familiar with the emergency descent procedures
    - b. Bear in mind that:
      - The aircraft may be severely damaged to the point that its ability to remain under control could be lost at any moment
      - The aircraft may still be on fire and susceptible to explosion
      - The aircraft is expendable and the only thing that matters is the safety of those on board
- C. Electrical Fire
  - i. The initial indication of an electrical fire is usually the distinct odor or burning insulation
  - ii. Once detected, the pilot should attempt to identify the faulty circuit by checking circuit breakers, instruments, avionics, and lights
    - a. If the faulty circuit cannot be identified and flight conditions permit, the battery and alternator should be turned off to remove the possible source of the fire. However, any materials which have been ignited may continue to burn
  - iii. If electrical power is absolutely essential for flight, an attempt may be made to identify and isolate the faulty circuit by:
    - a. Turning off the Master switch
    - b. Turning off all individual electrical switches

        c. Turn the Master switch back on
        d. Turn on the electrical switches, one at a time, allowing a short time lapse after each switch to check for signs of odor, smoke, or sparks
        e. Follow the manufacturer's checklist if it recommends otherwise
    iv. The most prudent course of action is to land as soon as possible
D. Cabin Fire
    i. Cabin fires general result from one of three sources:
        a. Careless smoking on the part of the pilot and/or passengers
        b. Electrical system malfunctions
        c. Heating system malfunctions
    ii. A fire in the cabin presents the pilot with two immediate demands:
        a. Attacking the fire
            - Identify and shutdown the faulty system (follow the manufacturer's instructions)
            - Opening cabin air vents may remove the smoke from the cabin
                a This should be done only after the fire extinguished is used (if available)
                b If smoke increases in intensity when the air vents are opened, immediately close them
                    1. This indicates a possible fire in the heating system, nose compartment baggage area (if equipped), or that the increase in airflow is feeding the fire
        b. Getting the aircraft on the ground as quickly as possible
            - Use the emergency descent procedures to get on the ground as quickly as possible
            - Immediately don emergency oxygen and smoke goggles (if available)

2. Immediate Action Items and Emergency Procedures

A. Reference the manufacturer's POH for the procedures to be used in situations requiring an emergency descent
B. Know any immediate action items and in the case of an emergency descent, execute them immediately
    i. Be very familiar with the emergency descent procedures. You'll save a lot of time executing the immediate action items immediately, instead of having to look them up in the POH

3. Airspeed, to Include Airspeed Limitations

A. The descent should be made at the maximum allowable airspeed consistent with the procedure used (V_{NE}, V_{FE}, V_A, etc.) and the manufacturer's recommendations
    i. This provides increased drag and the loss of altitude as quickly as possible
B. V_{NE}
    i. Never Exceed speed provides the greatest airspeed and therefore the fastest descent
    ii. Flaps and gear (if retractable) cannot be extended in this situation
    iii. A high-speed descent could assist in putting out a fire, but could weaken the airplane structure
    iv. Distance: This will provide the maximum descent and shortest distance traveled
C. V_{LE} (maximum landing gear extended speed)
    i. If the gear is retractable, the gear can be extended and used as drag
        a. This usually provides a higher airspeed than at flaps extended speed while still providing additional drag
    ii. Distance: Still short distance; high drag and higher relative airspeed
D. V_{FE}
    i. The flaps should be used as recommended by the manufacturer
    ii. This will provide the most drag, for the fastest descent possible, without excessive airspeed
    iii. The slower speed would place less stress on the airframe
    iv. Distance: A medium distance; priority is still placed on losing altitude as quickly as possible, without excessive airspeed
E. V_A

   i. If the descent is made in turbulent conditions, comply with the design maneuvering speed
   ii. Distance: Likely farther than both V_{NE} and V_{FE}, depending on the maneuvering speed
F. Consider the pitch attitudes
   i. If V_{NE} is excessively high, a very steep, potentially very uncomfortable, pitch attitude will be required to obtain the desired descent rate
      a. Are you comfortable putting the nose 15-20+ degrees below the horizon?
   ii. Using flaps and/or gear at a slower airspeed may get a similar descent rate without the excessive pitch and airspeed allowing for a less stressful, easier emergency descent and level off
      a. Leveling off at V_{NE} can put a lot of stress on the airframe. Start the level off early and use smooth control inputs
G. Use the manufacturer's recommendations (they know what works best for the aircraft)

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Consider Altitude, Wind, Terrain, Obstructions, and Glide Distance

A. Altitude
   i. 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. Remember to take wind into account during the descent and approach to landing
         - It can have a large effect on your glide distance (headwind vs tailwind vs crosswind)
   ii. Maximum Demonstrated Crosswind Component
      a. Use the manufacturer's flight manual to find the maximum allowable crosswind component
      b. Don't exceed it, the aircraft may not be able to remain within the confines of the runway
   iii. Tailwind
      a. A tailwind increases the runway required for landing
         - Always verify the wind conditions and takeoff performance obtained are compatible with the runway of intended use
      b. The flight manual will publish a maximum tailwind for landing
         - Do not exceed this limit
C. Terrain
   i. Be familiar with and especially cautious of terrain during an emergency descent
      a. High speed, high rate of descents can catch the pilot off guard
      b. Start the level off early enough to preclude descending through the desired altitude and potentially impacting terrain
D. Obstructions
   i. Also, be familiar with obstructions that may pose a threat to an emergency descent
      a. Use the same procedures as with terrain and begin the level off early enough to preclude descending through the desired altitude at a high speed and high rate of descent and potentially impacting an obstruction
E. Glide Distance
   i. In the case the engine fails and the aircraft has to glide to the landing area the pilot should terminate the emergency descent at a time appropriate to the situation and transition to the 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

2. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance

i. Operation Lights On
   a. A voluntary FAA safety program to enhance the see and avoid concept
   b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
      - If they are different categories:
         a A balloon has the right of way over any other category
         b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
         c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
         d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
   c. Approaching Head-on
      - Each pilot shall alter course to the right
   d. Overtaking
      - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
   e. Landing
      - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
         a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
      - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
         a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons

        - Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure
    iv. Clearing Procedures
        a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
        b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
            - This is also more applicable to cruise, but can be used while the pattern, if necessary
        c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft
    v. Scanning
        a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
            - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
    i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
        a. Study sectionals and terminal area charts
        b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
        c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
    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
            - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
        b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
    i. Many structures exist that could significantly affect the safety of flight when operating below 500’ AGL and particularly below 200’ AGL
        a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
        b. Become familiar with any obstacles on the approach and departure path
        c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
        d. At and below 200’ AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
        e. NOTAMs are issued on lighted structures experiencing light outages
    ii. Antenna Towers
        a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
            - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure
    iii. Overhead Wires
        a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
        b. These wires and lines may or may not be lighted

c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft

a. Ensure proper clearance between the aircraft and obstacle

- If unsure of clearance, stop until you're sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

3. Improper Aircraft Configuration

A. Improper configurations change the rate of descent and may negate the information published in the POH

i. Configure the aircraft as described in the POH. If the gear or flaps are going to be extended, ensure to operate within the airspeed limitations for the configuration

B. Except when prohibited by the manufacturer, the power should be reduced to idle and the propeller control (if equipped) should be placed in the low pitch (high rpm) position to act as an aerodynamic brake and prevent excessive airspeed build up during the descent

4. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. The pilot's attention should be focused on the tasks at hand

a. Flying takes precedence

- Aviate, Navigate, Communicate
- In the case of a real-life emergency and emergency descent, it is essential the pilot is not distracted and can handle the task(s) at hand

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

a. Remove the distraction prior to it becoming enough of a hazard

iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.) which will only serve to further aggravate an already stressful, and dangerous situation

a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. A loss of situational awareness in any situation can be dangerous, especially during an emergency descent

i. Other Aircraft

a. Transitioning a large number of altitudes (both VFR and IFR) puts you at an increased risk of a midair collision

b. Be aware, scan for other aircraft – Simulated emergency descents should be made in a turn

- When initiating the descent, 30 – 45° bank should be established to maintain positive G's on the aircraft and allow scanning below/in the direction of turn (in reality, go to the landing area and, if you can, use the turn to assist in clearing)
- This will also allow the pilot to scan for emergency landing areas
- A radio call announcing descent intentions may be appropriate to alert other aircraft in the area

ii. Emergency Checklists

a. The emergency still needs to be handled

b. Ensure the checklists are taken care of in a timely manner, without distracting from the descent, etc.

- Divide your attention

iii. Communication

a. ATC can keep you safer and provide an additional layer of situational awareness
  - Not only can they inform you of other traffic, but they can move that traffic and recommend/clear landing areas in the area

iv. High Rates of Descent and Leveling Off
  a. The emergency descent introduces an excessive rate of descent in order to lose altitude as quickly as possible, if the level off is neglected or not managed well it is very easy to fly through the level off altitude
    - This leads to problems with setting up for landing (especially in the case of a power off landing), and being low to the ground with high rates of descent

v. Maintain situational awareness throughout the descent, divide your attention as necessary between flying, navigating, communicating, and the emergency situation

C. Task Management
  i. Attention needs to be divided between the various required tasks
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
      - By effectively dividing attention, the pilot can deter the chance of a stall and spin
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks
  iii. Recognize when you are getting behind the aircraft, 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
    c. Don't give up or overstress yourself. Take it one step at a time.

SKILLS

The applicant demonstrates the ability to:

1. Clear the area.
2. Establish and maintain the appropriate airspeed and configuration appropriate to the scenario specified by the evaluator and as covered in POH/AFM for the emergency descent.
3. Demonstrate orientation, division of attention and proper planning.
4. Use bank angle between 30° and 45° to maintain positive load factors during the descent.
5. Complete the appropriate checklist.

IX.B. Emergency Approach and Landing

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Immediate Actions Items and Emergency Procedures**
   - A. Immediate Actions Items and Emergency Procedures
     - i. Immediate action items will vary between aircraft. Generally, in the case of an emergency approach and landing the initial steps will be similar (Remember ABC):
       - a. Airspeed
         - Pitch for and trim the aircraft for best glide speed. Ensure the aircraft is properly configured (gear, flaps, and propeller settings) for the aircraft
           - a A constant altitude should be held with back pressure on the elevator until the airspeed decreases to the recommended glide speed
             1. Due to decreased downwash over the horizontal stabilizer without the engine operating, the nose will tend to lower of its own accord – the pilot must be prepared for this
           - b Once the airspeed has dissipated to best glide speed, the pitch attitude should be allowed to decrease to maintain that speed.
       - b. Best landing area
         - If possible, find a close by airport
           - a If GPS is available, use the Nearest page and based on glide performance make a decision as to whether or not the airport can be reached
             1. If the glide ratio is 11:1 (as in the DA20) - for every 1,000' AGL the aircraft glides about 2 miles (lose about 500' per mile)
                - a. 11' forward to 1' down, or 11,000' forward for every 1,000' down which equates to approximately a 500' descent per mile
         - Select a field within glide distance (check in front, behind, and to both sides of the aircraft)
           - a Preferably hard packed, long, smooth, and with no obstacles at the approach end
         - Be aware of wind direction/velocity for landing direction and gliding distance
           - a Attempt to land into the wind, although factors may dictate otherwise
             1. Insufficient altitude, ground obstacles (shorten the length of field), etc.
           - b A failure to estimate the approximate wind speed and direction can lead to problems during the approach/landing
             1. Smoke, trees, windsocks, wind lines on water are good indicators
             2. Be aware of and establish any necessary crab in relation to the wind
         - Be aware of traffic
         - Use a road and water last resorts
           - a Wires cross roads, may be too narrow - only use if clear of traffic/wires
           - b Water is very dangerous
       - c. Checklists
         - Execute the necessary checklists
   - B. Airspeed
     - i. Best Glide Speed

a. The best speed for the glide is one at which the aircraft will travel the greatest forward distance for a given loss of altitude in still air
    - The best glide speed corresponds to an angle of attack resulting in the least drag on the aircraft and giving the best lift-to-drag ratio (L/D_{MAX})

b. Any change in glide speed will result in a proportional change in glide ratio

c. Any speed other than the best glide speed results in more drag. Therefore, as the glide airspeed is reduced or increased, the glide ratio is also changed
    - When descending at a speed below the best glide speed, induced drag increases
    - When descending at a speed above the best glide speed, parasite drag increases
    - In both cases, the rate of descent will increase

ii. Maintain a constant gliding speed at the manufacturer's best glide speed and recommended configuration

a. Variations in speed nullify attempts at accuracy in judging gliding distance and the landing spot

C. Difference Between Best Glide Speed and Minimum Sink Speed

i. Best Glide Speed

a. The best speed for the glide is one at which the aircraft will travel the greatest forward distance for a given loss of altitude in still air

ii. Minimum Sink Speed

a. If you're more interested in staying in the air as long as possible to either fix the problem or to communicate your intentions and prepare for a forced landing, then minimum sink speed is what you'll need. This speed is rarely found in Pilot Operating Handbooks, but it will be a little slower than maximum glide range speed

D. Effect of Wind on Glide Distance

i. Tailwind increases glide distance due to the higher groundspeed

ii. Headwind decreases glide distance due to the lower groundspeed

iii. The descent will have to be managed appropriately

a. In the case of a tailwind, a slip may be necessary or drag devices may need to be used earlier

b. In the case of a headwind, the pilot may want to delay adding drag in order to reach the landing area

E. FAA Aviation Safety Topic – Best Glide Speed and Distance

2. Effects of Atmospheric Conditions, Including Wind, on Emergency Approach and Landing

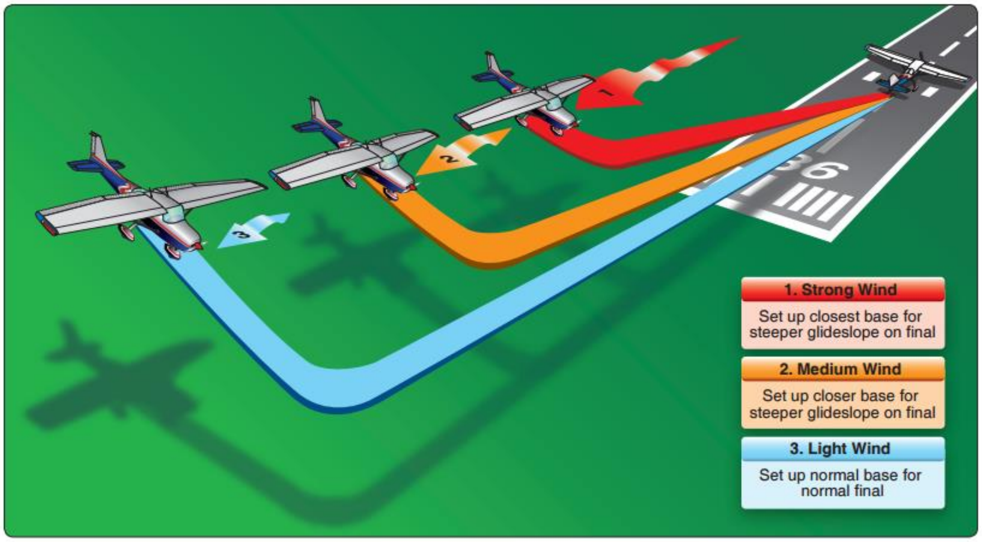
A. Wind

i. The approach path may be varied to compensate for winds

a. Always attempt to land into the wind

b. Once a landing site has been selected, proceed directly to the landing area and adjust the descent as necessary (spiral, slip, etc.) to at the normal key position at a normal traffic pattern altitude for the landing area

- The approach path can be varied by positioning the base leg closer to or farther out from the approach end of the runway according to wind conditions



ii. When spiraling over a landing area, adjust the spiral (like turns around a point) to prevent the wind from pushing the aircraft away
iii. Recognize the wind conditions based on windsocks at the airport, smoke from factories or houses, dust, brush fires, windmills, water, etc.

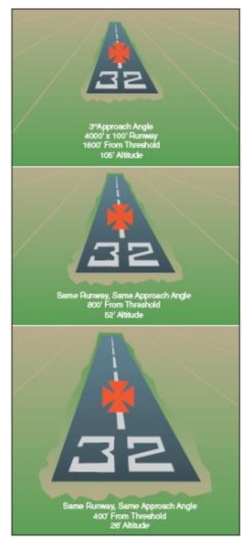
B. Updrafts and Downdrafts
 i. Updrafts and downdrafts can influence the aircraft's descent rate and the approach path
  a. The pilot will have to make adjustments based on changing conditions
  b. Updrafts can often be found on hot days over surfaces that radiate heat. Updrafts can transition to downdrafts when crossing over different terrain (for example, transitioning from hot pavement to trees)
   - Anticipate an increase in descent rate when the thermal activity dissipates

C. Density Altitude
 i. Density altitude is pressure altitude adjusted for non-standard temperature
 ii. Increased density altitude (lower pressure and/or higher temperature) increases the landing speed
  a. The aircraft lands at the same IAS, but because of reduced density (which can be a result of a lower pressure and/or a higher temperature), the true airspeed is greater
   - The higher the altitude, the higher the true airspeed (it takes a greater speed to create the same amount of lift in the thinner air at high altitude than the thicker air near sea level)

3. A Stabilized Approach, to Include Concepts of Energy Management

A. Reaching the Approach Point (abeam the landing point)
 i. Proceed directly to the selected landing area at best glide speed
  a. Use any combination of normal glide maneuvers (wings level, spirals, slips, etc.) to arrive at normal positions at normal pattern altitudes
   - If you are higher than pattern altitude, circle over the approach end down to pattern altitude
    a Know the approximate altitude that a 360° turn will lose to assist in planning the descent
    b If smaller corrections are needed, extend the spiral or slip for a short period
  b. The idea is to end up on downwind, abeam the landing point at a normal traffic pattern altitude for the area

        - Adjust the turns to roll out on downwind, abeam the landing point as close to pattern altitude as possible
   - ii. Divide attention between flying and accomplishing the checklists
      - a. Maintain reference to the landing field and best glide while performing the checklists
- B. A Stabilized Approach
   - 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.
      - a. A stabilized approach is a safe approach
      - b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
         - An unstable approach nullifies attempts at judging glide distance and the landing spot
   - ii. Controlling Descent
      - a. Normally adjust power and pitch as necessary to maintain a stabilized approach and glide slope
         - In the case of a power off approach, adjust pitch to maintain best glide speed and accept the rate of descent
            - a Any faster or any slower will increase the rate of descent, maintain best glide
         - Make adjustments to drag, flight path and airspeed (if necessary) to adjust the glidepath
            - a If the approach is high, add drag earlier than normal or increase the flight path to the touchdown zone (extend the base leg, or perform s-turns)
            - b If the approach is low, delay adding drag or decrease the path to the landing area (shortcut the turn to final)



   - iii. The Angle of Descent
      - a. Aiming Points
         - The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
         - Select a point in front of the point of intended touchdown
         - Keep the aiming point steady on the wind screen
            - a To a pilot moving straight ahead toward an object, the aiming point appears to be stationary, it does not move.
            - b If the point begins to move up on the windscreen the airplane is getting too low
               1. Delay drag
            - c If the point begins to move down on the windscreen the airplane is getting too high
               1. Add drag earlier than normal
               2. It is better to be high and make corrections down rather than be low without power and unable to correct up to the glidepath
            - d Small, active corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway
   - iv. Objective of a Stabilized Approach
      - a. To select an appropriate touchdown point on the runway, and adjust the glidepath as necessary to roundout at or above the aiming point, providing distance for the flare to touchdown at the landing point
- C. Energy Management
   - i. A stabilized approach is based on well executed energy management
      - a. This is essential in an emergency approach and landing
      - b. Main Points:

- Utilize any combination of normal gliding maneuvers to arrive abeam the landing point at a normal traffic pattern altitude for the area
    - a Usually this involves heading directly to the landing area and spiral overhead until ending up abeam the landing area at pattern altitude
- Perform a 180-degree power off approach to the landing area

c. Maintain best glide speed
- Speeds faster or slower than best glide will increase the rate of descent making a stable approach more difficult to manage

d. Drag Devices
- Add drag devices at normal positions in the approach unless otherwise required
    - a Normally, lower partial flaps on base and final flaps when the landing is assured
        1. This varies to an extent based on aircraft but it's the general idea
    - b If the glidepath is too low
        1. Delay adding drag devices and head directly to the landing zone
            a. Shortcut the turn to final
        2. Maintain best glide – other speeds will increase the descent, taking the aircraft farther below the glidepath
    - c If high on the glidepath
        1. Add drag devices earlier than normal
        2. Slip to return to the desired glidepath
        3. S-turn to increase the distance traveled to the landing zone
        4. Adjust airspeed to increase the rate of descent (be very careful and experienced performing this maneuver as it can be difficult to manage)
        5. As you can see there are many more ways to lose altitude than to get altitude back. It is safer to be high on the glidepath and make corrections than low without many, if any, options

4. ELTs and/or Other Emergency Locating Devices

A. ELT
- i. An ELT is required by FAR 91.207
- ii. The ELT is a device installed in the aircraft that will emit a distress signal that search and rescue teams can use to locate your aircraft
    - a. ELTs operate on one of three frequencies: 121.5, 243.0 or the newer 406 MHz
        - 121.5 and 243 are analog, while 406 is digital and can be encoded with the owner's contact info or aircraft data and can also be encoded with the aircraft's position

B. Emergency Locating Devices
- i. There are numerous commercial emergency locating devices available
    - a. GPS, satellite radios, etc.
    - b. Be familiar with the device you have

5. ATC Services to Aircraft in Distress

A. ATC facilities provide a variety of services to participating VFR aircraft on a workload permitting basis (in the case of an emergency/emergency descent, they will do everything in their power to help you)
- i. You must be able to communicate with ATC, be within radar coverage and be radar identified
- ii. Services provided include:
    - a. VFR radar traffic advisory service (Flight Following) and safety alerts
    - b. Vectoring (when requested)
    - c. Terminal Radar Programs (TRSA) – To separate all participating VFR aircraft and IFR traffic
    - d. Radar assistance to lost aircraft
    - e. Class C services include separation between IFR/VFR and sequencing of VFR traffic to the airport

        f. Class B services include separation based on IFR, VFR and/or weight and sequencing VFR arrivals
    iii. Use these services in normal situations for the extra layer of safety they provide, and in the case of an emergency you're already in contact with the controllers

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Consider Altitude, Wind, Terrain, Obstructions, and Available Landing Distance

- A. Altitude
    - i. Altitude will dictate the distance the aircraft can travel
        - a. Use AGL, not MSL. Depending on where you are flying these altitudes can be very different
    - ii. The goal is to put the aircraft at a normal pattern altitude at a normal key position
        - a. Adjust the descent/spiral as necessary to arrive at this location and altitude
- B. Wind
    - i. During the approach
        - a. Remember to take wind into account during the approach to landing
            - It can have an effect on your glide distance (headwind vs tailwind vs crosswind)
        - b. The stronger the wind on final, the closer the base leg needs to be to the runway to make a normal approach
    - ii. Maximum Demonstrated Crosswind Component
        - a. Use the manufacturer's flight manual to find the maximum allowable crosswind component
        - b. Don't exceed it as the aircraft may not be able to remain with the confines of the runway
    - iii. Tailwind
        - a. A tailwind increases the runway required for landing
            - This is hazardous especially for an emergency approach and landing. Only land with a tailwind if it is the safest option
        - b. The flight manual will publish a maximum tailwind for landing
            - Do not exceed this limit
- C. Terrain
    - i. Be familiar with and especially cautious of terrain during an emergency descent
        - a. High speed, high rate of descents can catch the pilot off guard
        - b. Start the level off early enough to preclude descending through the desired altitude and potentially impacting terrain
- D. Obstructions
    - i. Also, be familiar with obstructions that may pose a threat to an emergency descent
        - a. Use the same procedures as with terrain and begin the level off early enough to preclude descending through the desired altitude at a high speed and high rate of descent and potentially impacting an obstruction
- E. 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
            - This will come with experience

2. Failure to Plan and Follow a Flightpath to the Selected Landing Area

A. The more normal the pilot can make the approach (arriving at the key position at a normal altitude), the more normal the approach will be. This means a safer, more familiar approach for the pilot
   i. If altitude allows, plan to enter on a downwind, base or straight-in on final and make the approach look as normal as possible
      - Take into account the winds, terrain and local obstructions
   ii. The further away from the desired position and altitude the more the pilot has to use experiment with nonstandard, untested methods to make the landing area
B. If a mistake is made (off altitude, downwind or base too close or too far from the runway), then make adjustments
   i. If you're too far away, cut a corner, try to return to a normal sight picture for an emergency landing
   ii. If you're too close, extend, use S-turns, lower the flaps early, etc. to adjust back to a normal picture
C. Don't hesitate and wait for the situation to play out, if you see something isn't right, make the changes to get back on glidepath

3. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
   i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
   ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
         - If they are different categories:
            a A balloon has the right of way over any other category
            b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
            c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
            d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
      c. Approaching Head-on
         - Each pilot shall alter course to the right
      d. Overtaking
         - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
      e. Landing
         - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
            a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
         - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
            a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
    a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
        - 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’ of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
        - Over other than Congested Areas: 500’ above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500’ to any person, vessel, vehicle, or structure

iv. Clearing Procedures
    a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
    b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
        - This is also more applicable to cruise, but can be used while the pattern, if necessary
    c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning
    a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
  i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  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
        - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
  i. Many structures exist that could significantly affect the safety of flight when operating below 500’ AGL and particularly below 200’ AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200’ AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages
  ii. Antenna Towers

a. Extreme caution should be exercised below 2,000’ AGL due to numerous antennas that extend over 1,000’-2,000’ AGL. Most structures are supported by guy wires which are very difficult to see
   - Avoid all structures by at least 2,000’ as these wires can extend 1,500’ horizontally from a structure

iii. Overhead Wires
   a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
   b. These wires and lines may or may not be lighted
   c. Be extremely vigilant on takeoff and landing

iv. When taxiing scan vigilantly during taxi for other aircraft and obstacles that may interfere with your taxi or damage the aircraft
   a. Ensure proper clearance between the aircraft and obstacle
      - If unsure of clearance, stop until you’re sure it is safe to pass

v. If necessary, radio ground to inform them of your intentions or ask for assistance

4. Improper Aircraft Configuration

A. Normal Configuration
   i. The normal configuration (generally – this can vary based on aircraft) is to set partial flaps on the base turn and landing flaps when on final and the landing is assured is subject to change based on glidepath/altitude requirements
      a. If the approach is higher than normal drag can be added earlier
      b. If the approach is lower than normal drag can be delayed
   ii. Configuring outside of the normal positions can change the approach profile putting the pilot in an unfamiliar, learning situation during an emergency
      a. Attempt to keep the profile as close to normal as possible, only making corrections as necessary to return to, or maintain the glidepath

B. Improper configurations change the rate of descent and may negate the information published in the POH

C. Improperly configuring during the approach will increase the rate of descent and may result in not reaching the intended landing area

D. Configure the gear, flaps, and propeller as specified in the POH and as necessary during the approach to make the landing area

5. 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. Therefore, avoid distractions, maintain situational awareness, and fly precisely
      a. Precise flying (coordinated, and on speed) results in better aircraft performance (less drag, and higher rates of climb)

B. Be aware of, and avoid obstructions on and around the airfield
   i. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
   ii. Plan ahead to avoid obstacles

C. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination, and airspeed at low altitudes.
   i. Airspeed
      a. Maintaining a stabilized approach is essential to safety. Airspeed is a big part of a stabilized approach

        - Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
    b. If you get any indication of a stall at low level, recover promptly
        - Max, Relax, Roll is a common memory aid for stall recovery
            a In this case, max power is not an option, therefore, the pilot will have to relax back pressure, and add whatever nose down pressure is necessary to break the stall, roll wings level, and return to best glide speed
        - A stall recovery at during an emergency approach, at low altitude, without power, can greatly influence the aircraft's ability to make the landing area
            a Trim the aircraft for flight at best glide speed and monitor the airspeed through the descent. Turns can influence the speed, make adjustments as necessary during turn to maintain airspeed

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. The majority of CFIT incidents occur during final approach and landing
            - This becomes even more of an issue in the case of an emergency approach and landing
                a In the case the aircraft does not have power the pilot must be vigilant and aware of the surrounding terrain in order to avoid a situation in which he or she cannot maneuver away from terrain
                b Emergencies are huge distractions. Divide attention between the emergency situation and flying the aircraft. Do not become to consumed by the situation to allow the aircraft to fly into terrain
        b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
        c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
    iii. Recommendations:
        a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
        b. Know and fly above minimum published safe altitudes.
            - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
        c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
        d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
        e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
        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 outside the United States or 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.

6. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
    i. The pilot's attention should be focused on the tasks at hand

a. Flying takes precedence
    - Aviate, Navigate, Communicate
    - In the case of a real-life emergency approach and landing, it is essential the pilot is not distracted and can handle the task(s) at hand

b. At a relatively high altitude, with the greater choice of fields, the inexperienced pilot may be inclined to delay making a decision and with considerable altitude in which to maneuver, errors in maneuvering and estimation of glide distance may develop
    - Don't delay decision making, avoid distractions. Pick a landing field and head to it.

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
    a. Remove the distraction prior to it becoming enough of a hazard

iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, missed radio calls, unsafe descents or climbs, etc.) which will only serve to further aggravate an already stressful, and dangerous situation
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. A loss of situational awareness in any situation can be dangerous, especially during an emergency approach and landing
  i. Landing Area
    a. Select a landing area and proceed to it. Delaying the decision can lead to errors in maneuvering and estimation of glidepath
    b. Be aware of the wind conditions on the ground and structure the approach and landing to land into the wind
      - Adjust the pattern as necessary for the strength of the wind
  ii. Emergency Checklists
    a. The emergency still needs to be handled
    b. Ensure the checklists are taken care of in a timely manner, without distracting from the approach and landing, etc.
      - Divide your attention
  iii. Communication
    a. ATC can keep you safer and provide an additional layer of situational awareness
      - Not only can they inform you of other traffic, but they can move that traffic and recommend/clear landing areas in the area
  iv. Maintain situational awareness throughout the approach and landing, divide your attention as necessary between flying, navigating, communicating, and the emergency situation

C. Task Management
  i. Attention needs to be divided between the various required tasks
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
      - By effectively dividing attention, the pilot can deter the chance of a stall and spin
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks
  iii. Recognize when you are getting behind the aircraft, 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
c. Don't give up or overstress yourself. Take it one step at a time

SKILLS

The applicant demonstrates the ability to:

1. Establish and maintain the recommended best glide airspeed, ±10 knots.
2. Configure the airplane in accordance with POH/AFM and existing conditions.
3. Select a suitable landing area considering altitude, wind, terrain, obstructions, and available glide distance.
4. Plan and follow a flightpath to the selected landing area considering altitude, wind, terrain, and obstructions.
5. Prepare for landing as specified by the evaluator.
6. Complete the appropriate checklist.

IX.C. Systems and Equipment Malfunction

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Partial or Complete Power Loss Related to the Specific Powerplant, Including:**

   Since procedures and systems will vary greatly between aircraft, reference the Emergency Procedures contained in the manufacturer's POH for the following malfunctions.

   A. Engine Roughness or Overheat
   B. Carburetor Icing or Overheat
   C. Loss of Oil Pressure
   D. Fuel Starvation

2. **System and Equipment Malfunctions Specific to the Airplane, Including:**

   Since procedures and systems will vary greatly between aircraft, reference the Emergency Procedures contained in the manufacturer's POH for the following malfunctions.

   A. Electrical Malfunction
   B. Vacuum/Pressure, and Associated Flight Instruments Malfunction
   C. Pitot/Static System Malfunction
   D. Electronic Flight Deck Display Malfunction
   E. Landing Gear and/or Flap Malfunction
   F. Inoperative Trim

3. **Smoke, Fire, Engine Compartment Fire**

   A. Follow the manufacturer's emergency checklist to handle smoke, fire, engine compartment fires
   B. Engine Fire
      i. An engine fire is usually caused by a failure that allows a flammable substance such as fuel, oil or hydraulic fluid to come in contact with a hot surface
         a. Engine fires can be indicated by smoke and/or flames coming from the engine cowling. They can also be indicated by discoloration, bubbling, and/or melting of the engine cowling skin in cases where flames and/or smoke is not visible to the pilot
         b. By the time the pilot is aware of an engine fire, it is usually well developed
      ii. Follow the manufacturer's checklist
         a. You will likely shutdown the engine and prepare for an emergency landing
         b. An emergency descent may assist in extinguishing the flames
            - If the engine is shut down and the problem handled, it may be beneficial to stop the emergency descent to increase the glide distance
      iii. Engine fires which appear to have been extinguished have been known to rekindle with changes in airflow pattern and airspeed
         a. The pilot must be familiar with the emergency descent procedures
         b. Bear in mind that:
            - The aircraft may be severely damaged to the point that its ability to remain under control could be lost at any moment
            - The aircraft may still be on fire and susceptible to explosion
            - The aircraft is expendable and the only thing that matters is the safety of those on board
   C. Electrical Fire
      i. The initial indication of an electrical fire is usually the distinct odor or burning insulation

ii. Once detected, the pilot should attempt to identify the faulty circuit by checking circuit breakers, instruments, avionics, and lights
   a. If the faulty circuit cannot be identified and flight conditions permit, the battery and alternator should be turned off to remove the possible source of the fire. However, any materials which have been ignited may continue to burn
iii. If electrical power is absolutely essential for flight, an attempt may be made to identify and isolate the faulty circuit by:
   a. Turning off the Master switch
   b. Turning off all individual electrical switches
   c. Turn the Master switch back on
   d. Turn on the electrical switches, one at a time, allowing a short time lapse after each switch to check for signs of odor, smoke, or sparks
   e. Follow the manufacturer's checklist if it recommends otherwise
iv. The most prudent course of action is to land as soon as possible

D. Cabin Smoke or Fire
   i. Cabin fires general result from one of three sources:
      a. Careless smoking on the part of the pilot and/or passengers
      b. Electrical system malfunctions
      c. Heating system malfunctions
   ii. Smoke or fire in the cabin present the pilot with two immediate demands:
      a. Attacking the fire/smoke
         - Identify and shutdown the faulty system (follow the manufacturer's instructions)
         - Opening cabin air vents may remove the smoke from the cabin
            a This should be done only after the fire extinguished is used (if available)
            b If smoke increases in intensity when the air vents are opened, immediately close them
               1. This indicates a possible fire in the heating system, nose compartment baggage area (if equipped), or that the increase in airflow is feeding the fire
      b. Getting the aircraft on the ground as quickly as possible
         - Use the emergency descent procedures to get on the ground as quickly as possible
         - Immediately don emergency oxygen and smoke goggles (if available)

4. Any Other System Specific to the Airplane

A. Supplemental Oxygen
   i. Regulations
      a. Supplemental oxygen is required:
         - When at cabin altitudes from 12,500' – 14,000' for more than 30 minutes
         - Immediately at cabin altitudes above 14,000'
         - For every aircraft occupant above a cabin altitude of 15,000'
      b. For optimal protection, pilots are encouraged (not a regulation) to use supplemental oxygen anytime above 10,000' cabin altitude during the day, and 5,000' cabin altitude during the night
   ii. Types of Oxygen Systems
      a. Continuous Flow
         - Most common in GA planes
         - Usually for passengers and has a reservoir bag which collects oxygen from the system when 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 cabin air and the oxygen
    - The mask provides a tight seal and can be used safely up to 40,000’
c. Pressure Demand – oxygen is supplied to the mask under pressure at cabin altitudes above 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

iii. Aviator’s Breathing Oxygen
a. Aviator’s oxygen is specified at 99.5% pure oxygen and not more than .005mg of water per liter
    - It is recommended that aviator’s breathing oxygen be used at all times; medical and industrial oxygen may not be safe
b. Medical oxygen has too much water, which can collect in various parts of the system and freeze
    - Freezing may reduce/stop the flow of oxygen
c. Industrial oxygen is not intended for breathing and may have impurities in it (metal shavings, etc.)

iv. Care and Storage of High-Pressure Oxygen Bottles
a. If the airplane does not have a fixed installation bottle, portable oxygen equipment must be accessible in flight
b. Oxygen is usually stored at 1,800 – 2,200 psi
    - When the ambient temperature surrounding the cylinder decreases, pressure within will decrease
        - a If a drop in indicated pressure is noted due to temperature, there is no reason to suspect depletion of the supply
    - High pressure containers should be marked with the psi tolerance before filling to the pressure
c. Be aware of the danger of fire when using oxygen
    - Materials that are nearly fire proof in ordinary air may be susceptible to burning in pure oxygen
        - a Oils and greases may catch fire if exposed to pure oxygen and cannot be in oxygen systems
    - Smoking during any kind of oxygen equipment use is prohibited
    - Before each flight, thoroughly inspect and test all oxygen equipment
d. Examine the equipment - available supply, operational check, and assure it is readily available
e. To assure safety, periodic inspections and servicing should be done

B. Deicing

i. General
a. Different aircraft use different systems to deice/anti-ice primary surfaces (often the wings, tail, engines and sometimes the prop)
    - These systems can vary greatly; examples include:
        - a Weeping Wing
            1. The DA42, for example, uses the weeping wing system – an anti-ice mixture is stored in the nose and when the system is turned on, it is excreted through tiny holes or pores in the wing. The fluid runs over the wing while in flight (i.e., weeping wing). This system is used to prevent ice build-up in flight

b. Heated Surfaces
   1. Jet aircraft often take hot bleed air from the engines and vent it to the wings and tail in order to prevent ice build-up in cold/wet conditions

c. Boots
   1. Boots are also often used on jets to remove ice from critical surfaces. In the case of boots, bleed air is used to inflate the leading edge "boots" in order to break up and remove ice

ii. Many small general aviation aircraft don't contain any specific deice or anti-ice equipment, but two pieces of equipment that can have an effect on ice build-up are the pitot-heat and windshield defrost:
   a. Pitot Heat
      - Using pitot heat is absolutely necessary in the case of potential icing. Of course, make every attempt to get out of icing or get on the ground, but pitot heat can prevent a frozen pitot/static port and therefore unreliable instrument indications
   b. Windshield Defrost
      - Can be used to deice the windshield (if the icing is light)
      - This may provide additional, needed visibility while trying to exit the icing conditions, find an airport, and safely land the aircraft
   c. The bottom line: Avoid icing conditions. Don't fly. If you get in icing conditions, leave them as soon as possible.

5. Inadvertent Door or Window Opening

A. Follow the POH checklist to handle the situation

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to use the Proper Checklist During a System or Equipment Malfunction

A. Obviously, this is dangerous
   i. The problem is not being addressed and time is being spent dealing with something that may not be an issue (or is not as serious of an issue)
   ii. Analyze the situation; the big picture, not just the first thing you see and apply the proper checklist to handle the problem
   iii. In the case there are multiple problems, handle them in a logical order
      a. In general, this means to handle the most hazardous problem first. This makes sense, assuming that problem did not stem from another problem. In a situation where the most hazardous problem is a result of another issue, handle the root problem first.

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. The pilot's attention should be focused on the tasks at hand
      a. Flying takes precedence
         - Aviate, Navigate, Communicate
         - In the case of a real-life emergency, it is essential the pilot is not distracted and can handle the task(s) at hand
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Remove the distraction prior to it becoming enough of a hazard

iii. Distractions can lead to various dangerous situations, especially while handling an emergency and running a checklist (slow airspeeds, collisions, disorientation, missed radio calls, unusual attitudes, unsafe descents or climbs, etc.) which will only serve to further aggravate an already stressful, and dangerous situation
    a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed
    b. Accomplish a step or two of the checklist and then return to the aircraft. Crosscheck the speed, altitude, etc. and then return to the checklist for a step or two

B. A loss of situational awareness in any situation can be dangerous, especially during an emergency
  i. Emergency Checklists
    a. Ensure the checklists are taken care of in a timely manner, without distracting from the approach and landing, etc.
      - Divide your attention
  ii. Communication
    a. ATC can keep you safer and provide an additional layer of situational awareness
      - Not only can they inform you of other traffic, but they can move that traffic and recommend/clear landing areas in the area
  iii. Maintain situational awareness throughout the approach and landing, divide your attention as necessary between flying, navigating, communicating, and the emergency situation

C. Task Management
  i. Attention needs to be divided between the various required tasks
    a. No one responsibility should take your full attention full more than a short period
      - Continually move between tasks to ensure everything is being taken care of
      - By effectively dividing attention, the pilot can deter the chance of a stall and spin
    b. Safety is your number one priority
      - Aviate, Navigate, Communicate
  ii. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
    a. Checklists are extremely helpful in properly managing tasks
  iii. Recognize when you are getting behind the aircraft, 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
    c. Don’t give up or overstress yourself. Take it one step at a time

SKILLS

The applicant demonstrates the ability to:

1. Describe appropriate action for simulated emergencies specified by the evaluator from at least three of the elements or sub-elements listed in the K1 through K5 above.
2. Complete the appropriate checklist.

IX.D. Emergency Equipment and Survival Gear

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **ELT Operations, Limitations and Testing Requirements**
   - A. Operation
     - i. The ELT is a device installed in the aircraft that will emit a distress signal that search and rescue teams can use to locate your aircraft
     - ii. The ELT can be turned on manually, or if armed, is activate when subjected to crash generated forces
   - B. Limitations
     - i. The ELT is designed to emit for at least 48 hours
     - ii. Search and Rescue cannot respond as quickly to 121.5 ELTs because of the large number of false alerts and the lack of a quick means of verifying the status of an active 121.5 ELT
       - a. This can delay the search and rescue for hours, whereas a 406 MHz transponder can be verified quickly
     - iii. 121.5 and 243 MHz transponders are dependent on a nearby ATC facility picking up the ELT, or an overflying aircraft monitoring the frequency
   - C. 406 MHz ELTs can be narrowed to a much more confined search area than the older 121.5 and 243 MHz ELTs
     - i. 406 MHz ELTs also include a homing transmitter to aid searchers in finding the aircraft
   - D. Inspection/Testing
     - i. An ELT should be tested only during the first 5 minutes after any hour
     - ii. If operations require an ELT, it must be inspected every 12 calendar months
       - a. The inspection covers proper installation, battery corrosion, operating of the controls and crash sensor, and the presence of a sufficient signal radiated from its antenna
     - iii. Batteries must be replaced:
       - a. When the transmitter has been in use for more than 1 cumulative hour
       - b. When 50% of the battery useful life has expired
       - c. At the expiration date (which must be legibly marked on the outside of the transmitter and entered in the maintenance record)
2. **Fire Extinguisher Operations and Limitations**
   - A. Know the location and operation of the fire extinguisher(s) onboard the aircraft
   - B. Different fire extinguishers are only effective on certain types of fires. Be aware what type of extinguisher you have and what it is useful for
3. **Emergency Equipment and Survival Gear Needed For:**
   - A. General Equipment and Gear for all Situations
     - i. Emergency Equipment
       - a. A survival kit should provide sustenance, shelter, medical care and a means to summon help
     - ii. Gear to Meet the Basic Physical Needs Until Rescue
       - a. General Items to consider
         - i. First Aid Kit and Field Medical Guide
         - ii. Flashlight
         - iii. Water
         - vi. Matches
         - vii. Shelter
         - viii. Signaling Device

iv. Knife
v. Clothing for the climate
ix. Food

B. Climate Extremes (hot/cold)
   i. Different gear is required for different climates
      a. Adjust your survival gear based on the climate along your route of flight
      b. Warm clothes and layers are better suited for cold weather; finding water may be less of an issue than in hot climates
      c. Lighter clothes, but protection from the sun and a supply of water is likely more suitable in hot climates
   ii. Plan ahead based on where you're going to be flying
      a. You may pass through multiple climates, prepare for anything
         - For example, from the west coast to the Midwest
            a Traveling through California, over or through the Rocky Mountains, and into the plains in the Midwest will introduce a myriad of different climates
C. Mountainous Terrain
   i. Mountainous terrain can be hard to access
      a. Even if search and rescue knows where you are it may take time for them to reach you
      b. Pack for an extended stay
         - Shelter, warm clothing and food may be required
   ii. Weather
      a. Weather could vary considerably from your point of departure, or even from the bottom of the mountain. Be prepared for the extremes
         - Pack warm clothing and layers
   iii. Survival manuals are published commercially and by the government (item suggestions are included)
D. Overwater Operations
   i. While no Part 91 FAR requires survival gear for over water operations it is good to have life preservers and a lift raft to accommodate everyone on the airplane
      a. Especially if the aircraft will be operated beyond power off glide distance from the shore
         - Always have a plan – don't get yourself stranded over water without a way back to land and without survival gear
   ii. Survival in Water
      a. This is more complicated than on land: not only is movement limited to your raft, but food is limited to what you have on hand until you can find a way to catch your food
         - Surviving in the water is mentally exhausting
            a Overcome this and find ways to survive/locate rescue ships or aircraft
      b. Water is limited, especially in the ocean since salt water dehydrates the body and should not be used for drinking
      c. Sun burns can become an issue – protect yourself from the sun
E. Survival References
   i. AOPA Survival Safety
   ii. Basic Survival Skills for Aviation
   iii. Aircrew Survival Videos (YouTube)
   iv. Basic Survival Training - 1 Day Course
   v. Off Airport Ops Guide

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Plan for Basic Needs (Water, Clothing, Shelter) for 48 to 72 Hours

- A. Be Prepared
  - i. Keep a survival/medical kit in the aircraft with the basic necessities to survive anywhere
  - ii. If necessary, adjust the contents of the bag based on the time of year, and route of flight (terrain, weather, etc.)
  - iii. Not having the necessary survival equipment could lead to injury, sickness, inability to signal rescue teams, or worst case, death
    - a. Be prepared
- B. Be Educated
  - i. Be familiar with survival skills; take classes, read books
  - ii. Have a survival essentials book in your survival kit
  - iii. Understand that if you crash in an isolated hard to reach area it may take time for search and rescue to get to you even if they know where you are, be prepared to survive a few days
- C. Be Visible
  - i. Be visible on the ground
    - a. Use signs – smoke, arrange wood, rocks, etc. into noticeable shapes
    - b. Don't hide in the trees
  - ii. GPS locator
    - a. Carry a portable GPS locator that will relay coordinates in the case of an emergency
  - iii. Portable Radio
    - a. Pack a portable radio – broadcast on the emergency frequencies (121.5/243.0) to anyone (ATC or another aircraft that can relay your message and location)

SKILLS

The applicant demonstrates the ability to:

1. Identify appropriate equipment and personal gear.
2. Brief passengers on proper use of on-board emergency equipment and survival gear

IX.E. Engine Failure During Takeoff Before V_{MC}

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Factors Affecting V_{MC}

- A. V_{MC}
  - i. In aircraft certification, V_{MC} is the sea level calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5°
  - ii. V_{MC} and the Loss of Control
    - a. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
      - The rudder cannot maintain control and the plane yaws in the direction of the inoperative engine
    - b. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
  - iii. V_{MC} is not a fixed airspeed under all conditions
    - a. It is only a fixed airspeed for the very specific set of circumstances under which it was tested during aircraft certification
    - b. V_{MC} varies with a variety of factors
- B. Factors
  - i. Critical Engine Wind Milling
    - a. V_{MC} increases with increased drag on the inoperative engine
      - V_{MC} is therefore the highest when the critical engine prop is wind milling at the low pitch, high rpm blade angle
  - ii. Maximum Available Takeoff Power
    - a. V_{MC} increases as power is increased on the operating engine
  - iii. Density Altitude
    - a. V_{MC} decreases with increases in altitude or a decrease in density
      - Due to the lessened thrust at higher density altitudes, less yaw is experienced in relation to P-Factor
  - iv. Most Unfavorable Weight
    - a. V_{MC} is increased as weight is reduced
      - A heavier plane is a more stable and controllable plane
      - Also, the weight of the airplane assists in establishing and maintaining a zero-side slip
  - v. Most Unfavorable CG
    - a. V_{MC} increases as the CG is moved aft
      - The moment of the rudder arm is reduced, and therefore its effectivity is reduced
      - AND, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust
  - vi. Landing Gear Retracted
    - a. V_{MC} increases when the landing gear is retracted
      - Extended gear aids in directional stability, which tends to decrease V_{MC}

vii. Flaps in the takeoff Position
    a. Flaps in the takeoff position decreases V_{MC}
    b. Creates extra drag on the operating engine
        - This reduces the tendency to yaw toward the inoperative engine

viii. Cowl Flaps in the T/O position
    a. Open cowl flaps will produce more drag on the operative engine, therefore decreasing V_{MC}

ix. Airplane Trimmed for Takeoff
    a. This varies between aircraft due to different T-tail, low tail, type of elevator and trim setting

x. Airplane Airborne and Out of Ground Effect
    a. If in Ground Effect, as the airplane is banked into the operative engine it would generate more lift on the lowered wing, increasing the rolling tendency toward the inoperative engine (V_{MC} increases)

xi. Maximum 5° of Bank
    a. V_{MC} is highly sensitive to bank angle
        - To prevent claims of unrealistically low speeds, the bank into the operating engine is limited
    b. The horizontal component of lift from the bank assists the rudder in counteracting the asymmetrical thrust
    c. The bank angle works in the manufacturer's favor, lowering V_{MC}
    d. V_{MC} is reduced significantly with increases in bank and increases significantly with decreases
        - Tests have shown that V_{MC} may increase > 3 knots for each degree of bank less than 5°

Factor	Control	V_{MC}	Performance
CG – Forward	Increases	Decreases (Good)	Decreases
CG – Aft	Decreases	Increases (Bad)	Increases
Weight – Increase	Increases	Decreases (Good)	Decreases
Density Altitude – High	Increases	Decreases (Good)	Decreases
Gear – Up	Decreases	Increases (Bad)	Increases
Flaps – Up	Decreases	Increases (Bad)	Increase
Wind Milling Prop	Decreases	Increases (Bad)	Decreases
Max T/O Power	Depends	Increases (Bad)	Increases
Cowl Flaps Open	Increases (?)	Decreases (Good)	Decreases
Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases
Airborne/Out of GE	Decreases	Increases (Bad)	Decreases
Trimmed for T/O	Could go either way →		

2. V_{MC} (Red Line) and V_{YSE} (Blue Line)

A. V_{MC}

i. Minimum control speed with the critical engine inoperative under a very specific set of circumstances (above) outline in 14 CFR Part 23, Airworthiness Standards. Marked with a red radial line on most airspeed indicators
    a. Under the regulations currently in effect, the test pilot must be able to:
        - Stop the turn that results when the critical engine is suddenly made inoperative within 20-degrees of the original heading, using maximum rudder deflection and a maximum of 5-degrees of bank, and
        - Thereafter, maintain straight flight with not more than 5-degrees of bank
    b. There is no requirement that the aircraft be capable of climbing at this speed. V_{MC} only addresses directional control

B. V_{YSE}

i. Best rate-of-climb speed with one engine inoperative. Marked with a blue line on most airspeed indicators. Above the single engine absolute ceiling, V_{YSE} yields the minimum rate of sink
ii. Whereas VMC addresses directional control, V_{YSE} addresses the aircraft's ability to climb (or maintain the minimum sink) with an inoperative engine
    a. It is very important the pilot monitors airspeed to avoid slowing to V_{MC}

3. Accelerate/Stop Distance

A. Accelerate/Stop Distance
  i. The runway length required to accelerate to a specified speed (either V_R or V_{LOF}, as specified by the manufacturer), experience an engine failure, and bring the aircraft to a complete stop
    a. V_R: Rotation speed. The speed at which back pressure is applied to rotate the aircraft to a takeoff attitude
    b. V_{LOF}: Lift-off Speed. The speed at which the aircraft leaves the surface (Note: some manufacturers reference takeoff performance data to V_R, others to V_{LOF})
    c. The idea behind this speed is to know the maximum distance required to abort a takeoff. It takes into account the latest point at which an engine can fail prior to being airborne and stopping straight ahead.
  ii. Use the chart in the POH to determine the accelerate/stop distance for the environmental conditions and aircraft configuration
    a. Some aircraft flight manuals do not have an accelerate/stop chart. In this case, use the information you have to estimate the distance. For example, add the takeoff and landing distance together
      - Be aware of any limitations of this technique. For example, the aircraft is being brought to a stop from rotation speed, while the landing distance is determined using the approach speed. Additionally, the landing distance chart may or may not include a flare distance, or distance to clear an obstacle. Take all of these factors into account. Be realistic in your estimates and conservative in the case of uncertainty.
  iii. Regulations do not specifically require that the runway length be equal to or greater than the accelerate/stop distance. Most POHs publish accelerate/stop distance only as an advisory. It only becomes a limitation when published in the limitations section of the POH
    a. Experienced multiengine pilots, however recognize safety margin of runway lengths in excess of the bare minimum required for normal takeoff and will insist on runway lengths of at least accelerate/stop distance as a matter of safety and good operating practice

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Plan for Engine Failure During Takeoff

A. Departure Briefing
  i. Prior to departure brief the planned intentions, as well as the emergency procedures you plan to use in the case they become necessary
    a. This often includes the takeoff runway, takeoff distance available, takeoff and aborted takeoff distances, departure plans (direction, altitude, airspeeds, procedures, etc.), emergency conditions (if an engine fails prior to rotation, I will abort the takeoff on the runway, close the throttles, stop straight ahead, maintain directional control with the rudders and brakes; if an engine fails after rotation, I will…)
  ii. Plan Ahead!

        a. Rehearsing the steps you will take in the case of an emergency greatly enhances your situational awareness in the case one actually occurs
        b. It also helps to prevent startle response
            - Startle response is a largely unconscious defensive response to sudden or threatening stimuli, such as sudden noise or sharp movement, and is associated with negative affect. Usually the onset of the startle response is a startle reflex reaction.
            - A knee-jerk reaction is not conducive to handling an emergency. Be prepared and plan your actions in the case of an engine failure

2. Improper Aircraft Configuration

A. The aircraft should be configured for takeoff.
B. In the case of an engine failure before VMC the aircraft will not be taken airborne, and configuration will not need changed.
C. The throttles should be smoothly but positively closed to remove the uncontrollable yaw effect caused by an inoperative engine below VMC and the aircraft stopped straight ahead

3. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
    i. Fly first!
        a. Aviate, Navigate, Communicate
    ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
        a. Especially during takeoff, distractions can be very hazardous. Eliminate any distractions and fly the aircraft
B. Situational awareness is extremely important during takeoff - High power settings, and high speeds, while on the ground demand a need for situational awareness. A loss of situational awareness can lead to unsafe situations
    i. Be aware of the aircraft, your airspeed, the runway available and the runway required (takeoff distance, accelerate/stop distance, etc.)
    ii. Know the plan of action in the case of an engine failure or other emergency at different points
    iii. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
    iv. Maintain situational awareness
C. Task Management
    i. Your first job is always to control the aircraft. In this case, that means safely bringing it to a stop on the runway
        a. Once the emergency is handled, then move to additional tasks such as emergency checklists and communicating with ATC
    ii. Safety is your number one priority
        a. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
        b. Checklists are extremely helpful in properly managing tasks

SKILLS

The applicant demonstrates the ability to:

1. Close the throttles smoothly and promptly when a simulated engine failure occurs.
2. Maintain directional control and apply brakes (AMEL), as necessary.

IX.F. Engine Failure After Lift-Off

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Factors Affecting V_{MC}

- A. V_{MC}
  - i. In aircraft certification, V_{MC} is the sea level calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5°
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    - a. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
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    - b. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
  - iii. V_{MC} is not a fixed airspeed under all conditions
    - a. It is only a fixed airspeed for the very specific set of circumstances under which it was tested during aircraft certification
    - b. V_{MC} varies with a variety of factors
- B. Factors
  - i. Critical Engine Wind Milling
    - a. V_{MC} increases with increased drag on the inoperative engine
      - V_{MC} is therefore the highest when the critical engine prop is wind milling at the low pitch, high rpm blade angle
  - ii. Maximum Available Takeoff Power
    - a. V_{MC} increases as power is increased on the operating engine
  - iii. Density Altitude
    - a. V_{MC} decreases with increases in altitude or a decrease in density
      - Due to the lessened thrust at higher density altitudes, less yaw is experienced in relation to P-Factor
  - iv. Most Unfavorable Weight
    - a. V_{MC} is increased as weight is reduced
      - A heavier plane is a more stable and controllable plane
      - Also, the weight of the airplane assists in establishing and maintaining a zero-side slip
  - v. Most Unfavorable CG
    - a. V_{MC} increases as the CG is moved aft
      - The moment of the rudder arm is reduced, and therefore its effectivity is reduced
      - AND, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust
  - vi. Landing Gear Retracted
    - a. V_{MC} increases when the landing gear is retracted
      - Extended gear aids in directional stability, which tends to decrease V_{MC}

vii. Flaps in the takeoff Position
    a. Flaps in the takeoff position decreases V_{MC}
    b. Creates extra drag on the operating engine
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    a. Open cowl flaps will produce more drag on the operative engine, therefore decreasing V_{MC}

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    a. This varies between aircraft due to different T-tail, low tail, type of elevator and trim setting

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Flaps – Up	Decreases	Increases (Bad)	Increase
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Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases
Airborne/Out of GE	Decreases	Increases (Bad)	Decreases
Trimmed for T/O	Could go either way →		

2. V_{MC} (Red Line), V_{YSE} (Blue Line), and V_{SSE} (Safe Single-Engine Speed)

A. V_{MC}
    i. Minimum control speed with the critical engine inoperative under a very specific set of circumstances (above) outline in 14 CFR Part 23, Airworthiness Standards. Marked with a red radial line on most airspeed indicators
        a. Under the regulations currently in effect, the test pilot must be able to:
            - Stop the turn that results when the critical engine is suddenly made inoperative within 20-degrees of the original heading, using maximum rudder deflection and a maximum of 5-degrees of bank, and
            - Thereafter, maintain straight flight with not more than 5-degrees of bank
        b. There is no requirement that the aircraft be capable of climbing at this speed. V_{MC} only addresses directional control

B. V_{YSE}

i. Best rate-of-climb speed with one engine inoperative. Marked with a blue line on most airspeed indicators. Above the single engine absolute ceiling, V_{YSE} yields the minimum rate of sink
ii. Whereas VMC addresses directional control, V_{YSE} addresses the aircraft's ability to climb (or maintain the minimum sink) with an inoperative engine
    a. It is very important the pilot monitors airspeed to avoid slowing to V_{MC}

C. V_{SSE}
   i. Safe, intentional one-engine inoperative speed. Formally defined in 14 CFR Part 23, Airworthiness Standards, and required to be established and published in the AFM/POH. It is the minimum speed to intentionally render the critical engine inoperative

3. Accelerate/Stop and Accelerate/Go Distance

A. Accelerate/Stop Distance
   i. The runway length required to accelerate to a specified speed (either V_R or V_{LOF}, as specified by the manufacturer), experience an engine failure, and bring the aircraft to a complete stop
      a. V_R: Rotation speed. The speed at which back pressure is applied to rotate the aircraft to a takeoff attitude
      b. V_{LOF}: Lift-off Speed. The speed at which the aircraft leaves the surface (Note: some manufacturers reference takeoff performance data to V_R, others to V_{LOF})
      c. The idea behind this speed is to know the maximum distance required to abort a takeoff. It takes into account the latest point at which an engine can fail prior to being airborne and stopping straight ahead.
   ii. Use the chart in the POH to determine the accelerate/stop distance for the environmental conditions and aircraft configuration
      a. Some aircraft flight manuals do not have an accelerate/stop chart. In this case, use the information you have to estimate the distance. For example, add the takeoff and landing distance together
         - Be aware of any limitations of this technique. For example, the aircraft is being brought to a stop from rotation speed, while the landing distance is determined using the approach speed. Additionally, the landing distance chart may or may not include a flare distance, or distance to clear an obstacle. Take all of these factors into account. Be realistic in your estimates and conservative in the case of uncertainty.
   iii. Regulations do not specifically require that the runway length be equal to or greater than the accelerate/stop distance. Most POHs publish accelerate/stop distance only as an advisory. It only becomes a limitation when published in the limitations section of the POH
      a. Experienced multiengine pilots, however recognize safety margin of runway lengths in excess of the bare minimum required for normal takeoff and will insist on runway lengths of at least accelerate/stop distance as a matter of safety and good operating practice

B. Accelerate/Go Distance
   i. The horizontal distance required to continue the takeoff and climb to 50 feet, assuming an engine failure at V_R or V_{LOF}, as specified by the manufacturer
      a. V_R: Rotation speed. The speed at which back pressure is applied to rotate the aircraft to a takeoff attitude
      b. V_{LOF}: Lift-off Speed. The speed at which the aircraft leaves the surface (Note: some manufacturers reference takeoff performance data to V_R, others to V_{LOF})
   ii. Keep in mind that the accelerate/go distance, as long as it is, has only brought the aircraft, under ideal circumstances a mere 50 feet above the takeoff elevation
      a. To achieve even this meager climb, the pilot had to instantaneously recognize and react to an engine failure, retract the landing gear, identify and feather the correct engine, while maintaining precise airspeed control and bank angle as airspeed is nursed to VYSE

iii. Not all aircraft have published acceleration/go distances in the POH, and fewer still publish climb gradients
   a. When such information is published, the figures have been determined under ideal flight testing conditions. It is unlikely the performance will be duplicated in service conditions
iv. The point of this discussion is to illustrate the marginal climb performance of a multiengine airplane that suffers an engine failure shortly after takeoff, even under ideal conditions.
   a. The prudent multiengine pilot should pick a decision point in the takeoff and climb sequence in advance.
      - If an engine fails before this point the takeoff should be rejected, even if airborne, for a landing on whatever runway or surface lies essentially ahead.
      - If an engine fails after this point, the pilot should promptly execute the appropriate engine failure procedure and continue the climb, assuming the performance capability exists.
      - As a general recommendation, if the landing gear has not been selected up, the takeoff should be rejected, even if airborne.

4. How to Identify, Verify, Feather, and Secure an Inoperative Engine

A. Identify, and Verify the Inoperative Engine
   i. Dead Foot, Dead Engine
      a. When an engine fails the aircraft will yaw toward the dead engine, it will take rudder from the opposite side (the good engine side) to maintain control. The foot that is resting comfortably on the floor, not doing anything (the dead foot) is on the side of the dead engine
         - The foot doing all the work is on the side of the live engine
   ii. When time allows, a review of the engine instruments will confirm this
   iii. You'll find out very quickly if you got the wrong engine when you take the power on the "dead" engine to idle and everything gets quiet

B. Feather and Secure the Inoperative Engine
   i. Because procedures will vary between aircraft, follow the manufacturer's procedures
      a. Generally, securing a failed engine includes:
         - Mixture – Idle cut off
         - Magnetos – Off
         - Alternator – Off
         - Cowl Flap – Close
         - Boost Pump – Off
         - Fuel Selector – Off
         - Prop Sync – Off
         - Electrical Load – Reduce
         - Crossfeed – Consider
      b. Take a break from the checklist every step or two to check airspeed, altitude, heading, zero sideslip and engine instruments
         - Divide your attention, flying is most important

1. Importance of Drag Reduction, to Include Propeller Feathering, Gear and Flap Retraction, the Manufacturer's Recommended Control Input and its Relation to Zero Sideslip

A. Drag Reduction
   i. The general memory items for an engine failure can vary based on aircraft and manufacturer, but are generally:
      a. Maintain at least V_{YSE}
      b. Full Power
         - If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power

- FADEC equipped aircraft (like the DA42) just need to establish full power

c. Gear up
  - The gear creates a large amount of drag. Retracting the gear greatly assists the aircraft's ability to climb

d. Flaps Up
  - Flaps, like gear, should be retracted per the manufacturer's instructions. This will decrease drag as well, and increase the aircraft's performance

e. Identify

f. Verify

g. Fix or Feather
  - If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feathering the engine is a considerable reduction in drag and a considerable increase in aircraft performance.

ii. A demonstration of aircraft performance at V_{YSE} with the propeller feathered and not feathered is a great way to show the effects of leaving gear, flaps or an un-feathered propeller and how much it really affects the aircraft's performance

B. Zero Side Slip

i. A zero-sideslip configuration is a key element in best climb performance

a. In a single engine aircraft, or a multiengine aircraft with both engines operating, sideslip is eliminated when the ball of the turn and bank indicator is centered
  - This is a condition of zero sideslip, and the aircraft is presenting its smallest possible profile to the relative wind. As a result, drag is at a minimum. This is also known as coordinated flight

b. In a multiengine aircraft, with an inoperative engine, the centered ball is no longer the indicator of zero sideslip due to asymmetrical thrust
  - Minimizing sideslip is a matter of placing the aircraft at a predetermined bank angle and ball position

ii. Establish a zero-sideslip configuration by adding approximately 2-3^{o} of bank to counteract the roll and maintaining heading visually with rudder pressure (the aircraft will almost fall into a sideslip)

a. After a couple degrees of bank are established and rudder pressure is set to maintain heading double check the zero sideslip indications on the instruments and make changes needed (follow the manufacturer's recommended control inputs for a more exact zero sideslip)
  - A zero sideslip will vary based on the aircraft flown, but 1-3^{o} bank toward the operating engine and a third to a half ball deflection on the turn coordinator, toward the operating engine should be close

2. Zero Thrust Procedures

A. Simulate Propeller Feathering as recommended by the manufacturer

B. Zero thrust procedures will vary based on aircraft, but as mentioned the process is generally:

i. Maintain at least V_{YSE}

ii. Full Power

a. If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power

b. FADEC equipped aircraft (like the DA42) just need to establish full power

iii. Gear up

iv. Flaps Up

v. Identify

vi. Verify

vii. Feather the propeller

        a. If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feather the engine.
    viii. Trim Tabs
        a. Adjust as necessary
    ix. Secure the Failed Engine
        a. Follow the POH procedures, but generally, securing a failed engine includes:
            - Mixture – Idle cut off
            - Magnetos – Off
            - Alternator – Off
            - Cowl Flap – Close
            - Boost Pump – Off
            - Fuel Selector – Off
            - Prop Sync – Off
            - Electrical Load – Reduce
            - Crossfeed – Consider
    x. Land as soon as practical
    xi. Items a-g require immediate action and are to be accomplished from memory. Different aircraft have different procedures. The idea is to accomplish everything up to feathering the engine by memory
C. Ensure to establish and maintain a zero sideslip

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Failure to Plan for Engine Failure After Takeoff**
    A. Departure Briefing
        i. Prior to departure brief the planned intentions, as well as the emergency procedures you plan to use in the case they become necessary
            a. This often includes the takeoff runway, takeoff distance available, takeoff and aborted takeoff distances, departure plans (direction, altitude, airspeeds, procedures, etc.), emergency conditions (if an engine fails prior to rotation, I will abort the takeoff on the runway, close the throttles, stop straight ahead, maintain directional control with the rudders and brakes; if an engine fails after rotation, I will…)
        ii. Plan Ahead!
            a. Rehearsing the steps you will take in the case of an emergency greatly enhances your situational awareness in the case one actually occurs
            b. It also helps to prevent startle response
                - Startle response is a largely unconscious defensive response to sudden or threatening stimuli, such as sudden noise or sharp movement, and is associated with negative affect. Usually the onset of the startle response is a startle reflex reaction.
                - A knee-jerk reaction is not conducive to handling an emergency. Be prepared and plan your actions in the case of an engine failure
2. **Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires**
    A. Collision Avoidance
        i. Operation Lights On
            a. A voluntary FAA safety program to enhance the see and avoid concept

b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
- If they are different categories:
  - a A balloon has the right of way over any other category
  - b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
  - c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
  - d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
- Each pilot shall alter course to the right

d. Overtaking
- The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
- Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
  - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
- When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
  - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
- 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
- Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
- This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field

- Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain

i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield

a. Study sectionals and terminal area charts

b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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

- Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing

b. Become familiar with any obstacles on the approach and departure path

c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)

d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen

e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers

a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see

- Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires

a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)

b. These wires and lines may or may not be lighted

c. Be extremely vigilant on takeoff and landing

3. Improper Aircraft Configuration

A. Recognize the Engine Failure and Maintain Directional Control (establish a zero-sideslip)

i. An improper response can result in a loss of directional control. The aircraft is going to yaw toward the dead engine, not countering the with rudder and aileron could result in a loss of control or simply a roll toward the dead engine until impacting the ground

ii. The zero sideslip provides the least amount of drag (coordinated flight) to provide the best aircraft climb performance

a. This is necessary since half of the aircraft's power is gone

B. Full Power
   i. Since one engine is inoperative, maximize the power on the remaining engine
      a. Depending on atmospheric conditions and the aircraft's weight/configuration, not using full power could in the best case, result in a lower rate of climb than if the engine were at full power, or in the worst case, an inability to climb at all

C. Reduce Drag – Gear and Flaps Up
   i. Similar to using max power, reducing drag assists in the aircraft's ability to climb and accelerate
   ii. Leaving the gear or flaps hanging will inhibit the aircraft's ability to climb. Performance will be degraded

D. Identify

E. Verify

F. Fix or Feather
   i. Feathering the engine eliminates a large amount of drag. A failure to feather the engine can greatly inhibit the aircraft's climb performance

4. Low Altitude Maneuvering

A. Low Altitude Maneuvering
   i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
         - Precise flying (zero sideslip, on speed and altitude) results in better aircraft performance (less drag, and higher rates of climb)
      c. This is especially important with a failed engine: distractions can lead to a loss of control or airspeed falling below V_{MC}
   ii. Be aware of, and avoid obstructions on and around the airfield
      a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
   iii. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin
   i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination (zero sideslip), and airspeed at low altitudes. Do Not go below V_{MC}!
      a. Airspeed
         - Maintaining a stabilized climb or approach is essential to safety. Airspeed is a big part of being stabilized.
            a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
               1. V_{MC} will only make the situation worse, potentially unrecoverable (if the aircraft is stalled and below V_{MC} at a low altitude)
         - At the first indication of a stall or loss of control, perform the V_{MC} recovery
            a Take the power to idle, lower the nose to regain airspeed, and reintroduce power at a safe airspeed – climb back to pattern altitude and setup for another approach

C. CFIT (Controlled Flight into Terrain)
   i. AC 61-134: General Aviation CFIT Awareness
      a. This becomes even more of an issue in the case of an engine failure after liftoff
         - In the case the aircraft does not have power the pilot must be vigilant and aware of the surrounding terrain in order to avoid a situation in which he or she cannot maneuver away from terrain

- Emergencies are huge distractions. Divide attention between the emergency situation and flying the aircraft. Do not become to consumed by the situation to allow the aircraft to fly into terrain

ii. The solution to combating CFIT accidents starts on the ground
   a. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
   b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range

iii. Recommendations:
   a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
   b. Know and fly above minimum published safe altitudes.
      - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
   c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
   d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
   e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
   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 outside the United States or 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.

5. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
   i. Fly first!
      a. Aviate, Navigate, Communicate
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Situational awareness is extremely important when handling an engine failure, and a loss of situational awareness can lead to unsafe situations
   i. Be aware of the aircraft, its airspeed, configuration, pitch attitude, etc.
      a. Take breaks between executing the emergency checklist or memory items to fly the aircraft
   ii. Know the plan of action in the case of an engine failure or other emergency at different points
   iii. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
   iv. Maintain situational awareness

C. Task Management
   i. Your first job is always to control the aircraft. In this case, that means safely piloting the aircraft through the engine failure. Maintain directional control, ensure a safe airspeed, configure the aircraft appropriately and continuing with the necessary memory items and checklists
      a. Once the emergency is handled, then move to additional tasks such as additional checklists and communicating with ATC

ii. Safety is your number one priority
   a. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
   b. Checklists are extremely helpful in properly managing tasks

SKILLS

The applicant demonstrates the ability to:

1. Promptly recognize an engine failure, maintain control and utilize appropriate emergency procedures.
2. Establish V_{YSE}; if obstructions are present, establish V_{XSE} or V_{MC} +5 knots, whichever is greater, until obstructions are cleared, then transition to V_{YSE}.
3. Reduce drag by retracting landing gear and flaps in accordance with the manufacturer's guidance.
4. Simulate feathering the propeller on the inoperative engine. (Evaluator should then establish a zero-thrust on the inoperative engine).
5. Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
6. Monitor the operating engine and make adjustments as necessary.
7. Recognize the airplane's performance capabilities. If a climb is not possible at V_{YSE}, maintain V_{YSE} and return to the departure airport for landing, or initiate an approach to the most suitable landing area available.
8. Simulate securing the inoperative engine.
9. Maintain heading ±10°, and airspeed ±5 knots.
10. Complete the appropriate checklist.

IX.G. Approach and Landing with an Inoperative Engine

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Factors Affecting V_{MC}**
   - A. V_{MC}
     - i. In aircraft certification, V_{MC} is the sea level calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5°
     - ii. V_{MC} and the Loss of Control
       - a. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
         - The rudder cannot maintain control and the plane yaws in the direction of the inoperative engine
       - b. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
     - iii. V_{MC} is not a fixed airspeed under all conditions
       - a. It is only a fixed airspeed for the very specific set of circumstances under which it was tested during aircraft certification
       - b. V_{MC} varies with a variety of factors
   - B. Factors
     - i. Critical Engine Wind Milling
       - a. V_{MC} increases with increased drag on the inoperative engine
         - V_{MC} is therefore the highest when the critical engine prop is wind milling at the low pitch, high rpm blade angle
     - ii. Maximum Available Takeoff Power
       - a. V_{MC} increases as power is increased on the operating engine
     - iii. Density Altitude
       - a. V_{MC} decreases with increases in altitude or a decrease in density
         - Due to the lessened thrust at higher density altitudes, less yaw is experienced in relation to P-Factor
     - iv. Most Unfavorable Weight
       - a. V_{MC} is increased as weight is reduced
         - A heavier plane is a more stable and controllable plane
         - Also, the weight of the airplane assists in establishing and maintaining a zero-side slip
     - v. Most Unfavorable CG
       - a. V_{MC} increases as the CG is moved aft
         - The moment of the rudder arm is reduced, and therefore its effectivity is reduced
         - AND, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust
     - vi. Landing Gear Retracted
       - a. V_{MC} increases when the landing gear is retracted
         - Extended gear aids in directional stability, which tends to decrease V_{MC}

vii. Flaps in the takeoff Position
    a. Flaps in the takeoff position decreases V_{MC}
    b. Creates extra drag on the operating engine
        - This reduces the tendency to yaw toward the inoperative engine

viii. Cowl Flaps in the T/O position
    a. Open cowl flaps will produce more drag on the operative engine, therefore decreasing V_{MC}

ix. Airplane Trimmed for Takeoff
    a. This varies between aircraft due to different T-tail, low tail, type of elevator and trim setting

x. Airplane Airborne and Out of Ground Effect
    a. If in Ground Effect, as the airplane is banked into the operative engine it would generate more lift on the lowered wing, increasing the rolling tendency toward the inoperative engine (V_{MC} increases)

xi. Maximum 5° of Bank
    a. V_{MC} is highly sensitive to bank angle
        - To prevent claims of unrealistically low speeds, the bank into the operating engine is limited
    b. The horizontal component of lift from the bank assists the rudder in counteracting the asymmetrical thrust
    c. The bank angle works in the manufacturer's favor, lowering V_{MC}
    d. V_{MC} is reduced significantly with increases in bank and increases significantly with decreases
        - Tests have shown that V_{MC} may increase > 3 knots for each degree of bank less than 5°

Factor	Control	V_{MC}	Performance
CG – Forward	Increases	Decreases (Good)	Decreases
CG – Aft	Decreases	Increases (Bad)	Increases
Weight – Increase	Increases	Decreases (Good)	Decreases
Density Altitude – High	Increases	Decreases (Good)	Decreases
Gear – Up	Decreases	Increases (Bad)	Increases
Flaps – Up	Decreases	Increases (Bad)	Increase
Wind Milling Prop	Decreases	Increases (Bad)	Decreases
Max T/O Power	Depends	Increases (Bad)	Increases
Cowl Flaps Open	Increases (?)	Decreases (Good)	Decreases
Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases
Airborne/Out of GE	Decreases	Increases (Bad)	Decreases
Trimmed for T/O	Could go either way →		

2. V_{MC} (Red Line), and V_{YSE} (Blue Line)

A. V_{MC}

i. Minimum control speed with the critical engine inoperative under a very specific set of circumstances (above) outline in 14 CFR Part 23, Airworthiness Standards. Marked with a red radial line on most airspeed indicators
    a. Under the regulations currently in effect, the test pilot must be able to:
        - Stop the turn that results when the critical engine is suddenly made inoperative within 20-degrees of the original heading, using maximum rudder deflection and a maximum of 5-degrees of bank, and
        - Thereafter, maintain straight flight with not more than 5-degrees of bank
    b. There is no requirement that the aircraft be capable of climbing at this speed. V_{MC} only addresses directional control

B. V_{YSE}

i. Best rate-of-climb speed with one engine inoperative. Marked with a blue line on most airspeed indicators. Above the single engine absolute ceiling, V_{YSE} yields the minimum rate of sink
ii. Whereas VMC addresses directional control, V_{YSE} addresses the aircraft's ability to climb (or maintain the minimum sink) with an inoperative engine
    a. It is very important the pilot monitors airspeed to avoid slowing to V_{MC}

3. How to Identify, Verify, Feather and Secure the Inoperative Engine

A. Identify and Verify the Inoperative Engine
  i. Dead Foot, Dead Engine
    a. When an engine fails the aircraft will yaw toward the dead engine, it will take rudder from the opposite side (the good engine side) to maintain control. The foot that is resting comfortably on the floor, not doing anything (the dead foot) is on the side of the dead engine
      - The foot doing all the work is on the side of the live engine
  ii. When time allows, a review of the engine instruments will confirm this
  iii. You'll find out very quickly if you got the wrong engine when you take the power on the "dead" engine to idle and everything gets quiet

B. Feather and Secure the Inoperative Engine
  i. Because procedures will vary between aircraft, follow the manufacturer's procedures
    a. Generally, securing a failed engine includes:
      - Mixture – Idle cut off
      - Magnetos – Off
      - Alternator – Off
      - Cowl Flap – Close
      - Boost Pump – Off
      - Fuel Selector – Off
      - Prop Sync – Off
      - Electrical Load – Reduce
      - Crossfeed – Consider
    b. Take a break from the checklist every step or two to check airspeed, altitude, heading, zero sideslip and engine instruments
      - Divide your attention, flying is most important

4. Importance of Drag Reduction, to Include Propeller Feathering, Gear and Flap Retraction, the Manufacturer's Recommended Flight Control Input and its Relation to Zero Sideslip

A. Drag Reduction
  i. The general memory items for an engine failure can vary based on aircraft and manufacturer, but are generally:
    a. Maintain at least V_{YSE}
    b. Full Power
      - If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power
      - FADEC equipped aircraft (like the DA42) just need to establish full power
    c. Gear up
      - The gear creates a large amount of drag. Retracting the gear greatly assists the aircraft's ability to climb
    d. Flaps Up
      - Flaps, like gear, should be retracted per the manufacturer's instructions. This will decrease drag as well, and increase the aircraft's performance
    e. Identify
    f. Verify

g. Fix or Feather
    - If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feathering the engine is a considerable reduction in drag and a considerable increase in aircraft performance.

ii. A demonstration of aircraft performance at V_{YSE} with the propeller feathered and not feathered is a great way to show the effects of leaving gear, flaps or an un-feathered propeller, and how much it really affects the aircraft's performance

B. Zero Side Slip
  i. A zero-sideslip configuration is a key element in best climb performance
    a. In a single engine aircraft, or a multiengine aircraft with both engines operating, sideslip is eliminated when the ball of the turn and bank indicator is centered
      - This is a condition of zero sideslip, and the aircraft is presenting its smallest possible profile to the relative wind. As a result, drag is at a minimum. This is also known as coordinated flight
    b. In a multiengine aircraft, with an inoperative engine, the centered ball is no longer the indicator of zero sideslip due to asymmetrical thrust
      - Minimizing sideslip is a matter of placing the aircraft at a predetermined bank angle and ball position
  ii. Establish a zero-sideslip configuration by adding approximately 2-3^{o} of bank to counteract the roll and maintaining heading visually with rudder pressure (the aircraft will almost fall into a sideslip)
    a. After a couple degrees of bank are established and rudder pressure is set to maintain heading double check the zero sideslip indications on the instruments and make changes needed
      - A zero sideslip will vary based on the aircraft flown, but 1-3^{o} bank toward the operating engine and a third to a half ball deflection on the turn coordinator, toward the operating engine should be close (follow the manufacturer's recommended control inputs for a more exact zero sideslip)

5. Feathering and Zero Thrust Procedures

A. Simulate feathering the engine as recommended by the manufacturer (as specified in the Skills section of this task, the examiner should then establish zero thrust on the inoperative engine)

B. Feathering (not simulated)
  i. Feathering the aircraft reduces a considerable amount of drag, significantly increasing aircraft performance
    a. Feather the propeller as specified in the POH (this requires immediate action and should be accomplished from memory)
    b. Take a break from the checklist every step or two to check airspeed, altitude, heading, zero sideslip and engine instruments
      - Flying is most important
  ii. Before feathering the engine ALWAYS verify you have the correct engine
  iii. Once feathered, rudder can be reduced
    a. Yaw toward the dead engine is reduced since the drag on the inoperative propeller is reduced
    b. Adjust the controls to maintain the zero sideslip (less rudder and aileron)

C. Zero thrust procedures will vary based on aircraft, but as mentioned the process is generally:
  i. Maintain at least V_{YSE}
  ii. Full Power
    a. If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power
    b. FADEC equipped aircraft (like the DA42) just need to establish full power
  iii. Gear up
  iv. Flaps Up

v. Identify
vi. Verify
vii. Feather the propeller
    a. If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feather the engine.
viii. Trim Tabs
    a. Adjust as necessary
ix. Secure the Failed Engine
    a. Follow the POH procedures, but generally, securing a failed engine includes:
        - Mixture – Idle cut off
        - Magnetos – Off
        - Alternator – Off
        - Cowl Flap – Close
        - Boost Pump – Off
        - Fuel Selector – Off
        - Prop Sync – Off
        - Electrical Load – Reduce
        - Crossfeed – Consider
x. Land as soon as practical
xi. Certain engine failure checklist items are to be accomplished from memory. Different aircraft have different procedures. The idea is to accomplish everything up to feathering the engine by memory

D. Ensure to establish and maintain a zero sideslip

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Plan for Engine Failure Inflight or During an Approach

A. Be prepared & plan ahead!
    i. Rehearsing the steps you will take in the case of an emergency greatly enhances your situational awareness in the case one actually occurs
        a. It also helps to prevent startle response
            - Startle response is a largely unconscious defensive response to sudden or threatening stimuli, such as sudden noise or sharp movement, and is associated with negative affect. Usually the onset of the startle response is a startle reflex reaction.
            - A knee-jerk reaction is not conducive to handling an emergency. Be prepared and plan your actions in the case of an engine failure

2. Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires

A. Collision Avoidance
    i. Operation Lights On
        a. A voluntary FAA safety program to enhance the see and avoid concept
        b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000’, day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
    ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
    - If they are different categories:
        a A balloon has the right of way over any other category
        b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
        c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
        d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft

c. Approaching Head-on
    - Each pilot shall alter course to the right

d. Overtaking
    - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
    - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
        a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
    - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
        a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)

a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
    - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
    - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures

a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots

b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
    - This is also more applicable to cruise, but can be used while the pattern, if necessary

c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
    - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
      c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
   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
         - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
      b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
   i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
      a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
      b. Become familiar with any obstacles on the approach and departure path
      c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
      d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
      e. NOTAMs are issued on lighted structures experiencing light outages
   ii. Antenna Towers
      a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
         - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
   iii. Overhead Wires
      a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
      b. These wires and lines may or may not be lighted
      c. Be extremely vigilant on takeoff and landing

3. Improper Aircraft Configuration

A. Recognize the Engine Failure and Maintain Directional Control (establish a zero-sideslip)
   i. An improper response can result in a loss of directional control. The aircraft is going to yaw toward the dead engine, not countering the with rudder and aileron could result in a loss of control or simply a roll toward the dead engine until impacting the ground
   ii. The zero sideslip provides the least amount of drag (coordinated flight) to provide the best aircraft climb performance
      a. This is necessary since half of the aircraft's power is gone

B. Full Power
   i. Since one engine is inoperative, maximize the power on the remaining engine
      a. Depending on atmospheric conditions and the aircraft's weight/configuration, not using full power could in the best case, result in a lower rate of climb than if the engine were at full power, or in the worst case, an inability to climb at all

C. Reduce Drag – Gear and Flaps Up

    i. Similar to using max power, reducing drag assists in the aircraft's ability to climb and accelerate
    ii. Leaving the gear or flaps hanging will inhibit the aircraft's ability to climb. Performance will be degraded
  D. Identify
  E. Verify
  F. Fix or Feather
    i. Feathering the engine eliminates a large amount of drag. A failure to feather the engine can greatly inhibit the aircraft's climb performance

4. Low Altitude Maneuvering

  A. Low Altitude Maneuvering
    i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
        - Precise flying (zero sideslip, on speed and altitude) results in better aircraft performance (less drag, and higher rates of climb)
      c. This is especially important with a failed engine: distractions can lead to a loss of control or airspeed falling below V_{MC}
    ii. Be aware of, and avoid obstructions on and around the airfield
      a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
    iii. Plan ahead to avoid obstacles
  B. Low Altitude Stall/Spin
    i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination (zero sideslip), and airspeed at low altitudes. Do Not go below V_{MC}!
      a. Airspeed
        - Maintaining a stabilized climb or approach is essential to safety. Airspeed is a big part of being stabilized.
          a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
            1. V_{MC} will only make the situation worse, potentially unrecoverable (if the aircraft is stalled and below V_{MC} at a low altitude)
        - At the first indication of a stall or loss of control, perform the V_{MC} recovery
          a Take the power to idle, lower the nose to regain airspeed, and reintroduce power at a safe airspeed – climb back to pattern altitude and setup for another approach
  C. 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. The majority of CFIT incidents occur during final approach and landing
        - This becomes even more of an issue in the case of an emergency approach and landing
          a In the case the aircraft does not have power the pilot must be vigilant and aware of the surrounding terrain in order to avoid a situation in which he or she cannot maneuver away from terrain
          b Emergencies are huge distractions. Divide attention between the emergency situation and flying the aircraft. Do not become to consumed by the situation to allow the aircraft to fly into terrain
      b. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight

c. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range

iii. Recommendations:

a. Non-instrument rated VFR pilots should not attempt to fly in IMC.

b. Know and fly above minimum published safe altitudes.

- VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.

d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.

e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.

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 outside the United States or 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.

5. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. Fly first!

a. Aviate, Navigate, Communicate

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Situational awareness is extremely important when handling an engine failure, and a loss of situational awareness can lead to unsafe situations

i. Be aware of the aircraft, its airspeed, configuration, pitch attitude, etc.

a. Take breaks between executing the emergency checklist or memory items to fly the aircraft

ii. Know the plan of action in the case of an engine failure or other emergency at different points

iii. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio

iv. Maintain situational awareness

C. Task Management

i. Your first job is always to control the aircraft. In this case, that means safely piloting the aircraft through the engine failure. Maintain directional control, ensure a safe airspeed, configure the aircraft appropriately and continuing with the necessary memory items and checklists

a. Once the emergency is handled, then move to additional tasks such as additional checklists and communicating with ATC

ii. Safety is your number one priority

a. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.

b. Checklists are extremely helpful in properly managing tasks

6. Possible Single-Engine Go-Around

A. Single-engine go-arounds must be avoided

i. As a practical matter in single-engine approaches, once the aircraft is on final approach with the landing gear and flaps extended, it is committed to land. If not on the intended runway, then on another runway, a taxiway, or grassy infield.
ii. The light twin does not have performance to climb on one engine with landing gear and flaps extended
iii. Considerable altitude will be lost while maintaining V_{YSE} and retracting landing gear and flaps
    a. Losses of 500’ or more are not unusual
iv. If the landing gear has been lowered with an alternate means of extension, retraction may not be possible, virtually negating any climb capability

B. Consult the POH for performance information, and have a flight instructor perform a demonstration (at a safe altitude) of the performance capabilities of the aircraft in various configurations with and without the propeller feathered

C. Make the decision to discontinue the approach early (prior to extending gear and flaps), preferably even before starting the descent to land
    i. This will allow the pilot to continue around the pattern and begin the descent when confident in the approach path

SKILLS

The applicant demonstrates the ability to:

1. Promptly recognize an engine failure and maintain positive aircraft control. Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine).
2. Use flight controls in the proper combination as recommended by the manufacturer or as required to maintain best performance, and trim as required.
3. Follow the manufacturer’s recommended emergency procedures.
4. Monitor the operating engine and make adjustments as necessary.
5. Maintain the manufacturer’s recommended approach airspeed +10/-5 knots, in the landing configuration with a stabilized approach, until landing is assured.
6. Make smooth, timely, and correct control applications, during round out and touchdown.
7. Touch down on the first one-third of available runway/landing surface, with no drift and the airplane’s longitudinal axis aligned with and over the runway center or landing path.
8. Maintain crosswind correction and directional control throughout the approach and landing.
9. Complete the appropriate checklist.

MULTIENGINE OPERATIONS

X.A. Maneuvering with One Engine Inoperative

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Factors Affecting V_{MC}**
   - A. V_{MC}
     - i. In aircraft certification, V_{MC} is the sea level calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5°
     - ii. V_{MC} and the Loss of Control
       - a. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
         - The rudder cannot maintain control and the plane yaws in the direction of the inoperative engine
       - b. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
     - iii. V_{MC} is not a fixed airspeed under all conditions
       - a. It is only a fixed airspeed for the very specific set of circumstances under which it was tested during aircraft certification
       - b. V_{MC} varies with a variety of factors
   - B. Factors
     - i. Critical Engine Wind Milling
       - a. V_{MC} increases with increased drag on the inoperative engine
         - V_{MC} is therefore the highest when the critical engine prop is wind milling at the low pitch, high rpm blade angle
     - ii. Maximum Available Takeoff Power
       - a. V_{MC} increases as power is increased on the operating engine
     - iii. Density Altitude
       - a. V_{MC} decreases with increases in altitude or a decrease in density
         - Due to the lessened thrust at higher density altitudes, less yaw is experienced in relation to P-Factor
     - iv. Most Unfavorable Weight
       - a. V_{MC} is increased as weight is reduced
         - A heavier plane is a more stable and controllable plane
         - Also, the weight of the airplane assists in establishing and maintaining a zero-side slip
     - v. Most Unfavorable CG
       - a. V_{MC} increases as the CG is moved aft
         - The moment of the rudder arm is reduced, and therefore its effectivity is reduced
         - AND, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust
     - vi. Landing Gear Retracted
       - a. V_{MC} increases when the landing gear is retracted
         - Extended gear aids in directional stability, which tends to decrease V_{MC}

vii. Flaps in the takeoff Position
   a. Flaps in the takeoff position decreases V_{MC}
   b. Creates extra drag on the operating engine
      - This reduces the tendency to yaw toward the inoperative engine

viii. Cowl Flaps in the T/O position
   a. Open cowl flaps will produce more drag on the operative engine, therefore decreasing V_{MC}

ix. Airplane Trimmed for Takeoff
   a. This varies between aircraft due to different T-tail, low tail, type of elevator and trim setting

x. Airplane Airborne and Out of Ground Effect
   a. If in Ground Effect, as the airplane is banked into the operative engine it would generate more lift on the lowered wing, increasing the rolling tendency toward the inoperative engine (V_{MC} increases)

xi. Maximum 5° of Bank
   a. V_{MC} is highly sensitive to bank angle
      - To prevent claims of unrealistically low speeds, the bank into the operating engine is limited
   b. The horizontal component of lift from the bank assists the rudder in counteracting the asymmetrical thrust
   c. The bank angle works in the manufacturer's favor, lowering V_{MC}
   d. V_{MC} is reduced significantly with increases in bank and increases significantly with decreases
      - Tests have shown that V_{MC} may increase > 3 knots for each degree of bank less than 5°

Factor	Control	V_{MC}	Performance
CG – Forward	Increases	Decreases (Good)	Decreases
CG – Aft	Decreases	Increases (Bad)	Increases
Weight – Increase	Increases	Decreases (Good)	Decreases
Density Altitude – High	Increases	Decreases (Good)	Decreases
Gear – Up	Decreases	Increases (Bad)	Increases
Flaps – Up	Decreases	Increases (Bad)	Increase
Wind Milling Prop	Decreases	Increases (Bad)	Decreases
Max T/O Power	Depends	Increases (Bad)	Increases
Cowl Flaps Open	Increases (?)	Decreases (Good)	Decreases
Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases
Airborne/Out of GE	Decreases	Increases (Bad)	Decreases
Trimmed for T/O	Could go either way →		

2. V_{MC} (Red Line), and V_{YSE} (Blue Line)

A. V_{MC}

i. Minimum control speed with the critical engine inoperative under a very specific set of circumstances (above) outline in 14 CFR Part 23, Airworthiness Standards. Marked with a red radial line on most airspeed indicators
   a. Under the regulations currently in effect, the test pilot must be able to:
      - Stop the turn that results when the critical engine is suddenly made inoperative within 20-degrees of the original heading, using maximum rudder deflection and a maximum of 5-degrees of bank, and
      - Thereafter, maintain straight flight with not more than 5-degrees of bank
   b. There is no requirement that the aircraft be capable of climbing at this speed. V_{MC} only addresses directional control

B. V_{YSE}

i. Best rate-of-climb speed with one engine inoperative. Marked with a blue line on most airspeed indicators. Above the single engine absolute ceiling, V_{YSE} yields the minimum rate of sink
ii. Whereas VMC addresses directional control, V_{YSE} addresses the aircraft's ability to climb (or maintain the minimum sink) with an inoperative engine
   a. It is very important the pilot monitors airspeed to avoid slowing to V_{MC}

3. How to Identify, Verify, Feather, and Secure an Inoperative Engine

A. Identify and Verify the Inoperative Engine
   i. Dead Foot, Dead Engine
      a. When an engine fails the aircraft will yaw toward the dead engine, it will take rudder from the opposite side (the good engine side) to maintain control. The foot that is resting comfortably on the floor, not doing anything (the dead foot) is on the side of the dead engine
         - The foot doing all the work is on the side of the live engine
   ii. When time allows, a review of the engine instruments will confirm this
   iii. You'll find out very quickly if you got the wrong engine when you take the power on the "dead" engine to idle and everything gets quiet

B. Feather and Secure the Inoperative Engine
   i. Because procedures will vary between aircraft, follow the manufacturer's procedures
      a. Generally, securing a failed engine includes:
         - Mixture – Idle cut off
         - Magnetos – Off
         - Alternator – Off
         - Cowl Flap – Close
         - Boost Pump – Off
         - Fuel Selector – Off
         - Prop Sync – Off
         - Electrical Load – Reduce
         - Crossfeed – Consider
      b. Take a break from the checklist every step or two to check airspeed, altitude, heading, zero sideslip and engine instruments
         - Divide your attention, flying is most important

4. Importance of Drag Reduction, to Include Propeller Feathering, Gear and Flap Retraction, the Manufacturer's Recommended Flight Control Input and its Relation to Zero Sideslip

A. Drag Reduction
   i. The general memory items for an engine failure can vary based on aircraft and manufacturer, but are generally:
      a. Maintain at least V_{YSE}
      b. Full Power
         - If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power
         - FADEC equipped aircraft (like the DA42) just need to establish full power
      c. Gear up
         - The gear creates a large amount of drag. Retracting the gear greatly assists the aircraft's ability to climb
      d. Flaps Up
         - Flaps, like gear, should be retracted per the manufacturer's instructions. This will decrease drag as well, and increase the aircraft's performance
      e. Identify
      f. Verify

g. Fix or Feather
    - If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feathering the engine is a considerable reduction in drag and a considerable increase in aircraft performance.

ii. A demonstration of aircraft performance at V_{YSE} with the propeller feathered and not feathered is a great way to show the effects of leaving gear, flaps or an un-feathered propeller and how much it really affects the aircraft's performance

B. Zero Side Slip

i. A zero-sideslip configuration is a key element in best climb performance

a. In a single engine aircraft, or a multiengine aircraft with both engines operating, sideslip is eliminated when the ball of the turn and bank indicator is centered
    - This is a condition of zero sideslip, and the aircraft is presenting its smallest possible profile to the relative wind. As a result, drag is at a minimum. This is also known as coordinated flight

b. In a multiengine aircraft, with an inoperative engine, the centered ball is no longer the indicator of zero sideslip due to asymmetrical thrust
    - Minimizing sideslip is a matter of placing the aircraft at a predetermined bank angle and ball position

ii. Establish a zero-sideslip configuration by adding approximately 2-3^{o} of bank to counteract the roll and maintaining heading visually with rudder pressure (the aircraft will almost fall into a sideslip)

a. After a couple degrees of bank are established and rudder pressure is set to maintain heading double check the zero sideslip indications on the instruments and make changes needed
    - A zero sideslip will vary based on the aircraft flown, but 1-3^{o} bank toward the operating engine and a third to a half ball deflection on the turn coordinator, toward the operating engine should be close (follow the manufacturer's recommended control inputs for a more exact zero sideslip)

5. Feathering, Securing, Unfeathering, and Restarting

A. Feathering

i. Feathering the aircraft reduces a considerable amount of drag, significantly increasing aircraft performance

a. Feather the propeller as specified in the POH (this requires immediate action and should be accomplished from memory)

b. Take a break from the checklist every step or two to check airspeed, altitude, heading, zero sideslip and engine instruments
    - Flying is most important

ii. Before feathering the engine ALWAYS verify you have the correct engine

iii. Once feathered, rudder can be reduced

a. Yaw toward the dead engine is reduced since the drag on the inoperative propeller is reduced

b. Adjust the controls to maintain the zero sideslip (less rudder and aileron)

B. Zero thrust procedures will vary based on aircraft, but as mentioned the process is generally:

i. Maintain at least V_{YSE}

ii. Full Power

a. If so equipped, Mixture – Rich, Propeller – High RPM, Throttles – Full Power

b. FADEC equipped aircraft (like the DA42) just need to establish full power

iii. Gear up

iv. Flaps Up

v. Identify

vi. Verify

vii. Feather the propeller
   a. If altitude, time, and conditions permit, the pilot can attempt to fix or restart the engine. If not, feather the engine. (more below – Restart)
viii. Trim Tabs
   a. Adjust as necessary
ix. Secure the Failed Engine
   a. Follow the POH procedures, but generally, securing a failed engine includes:
      - Mixture – Idle cut off
      - Magnetos – Off
      - Alternator – Off
      - Cowl Flap – Close
      - Boost Pump – Off
      - Fuel Selector – Off
      - Prop Sync – Off
      - Electrical Load – Reduce
      - Crossfeed – Consider
x. In the case an engine restart can be attempted, the engine will be unfeathered and the restart attempted in accordance with the manufacturer's checklists.
xi. Land as soon as practical
xii. Certain items in relation to securing the engine are to be accomplished from memory. Different aircraft have different procedures. The idea is to accomplish everything up to feathering the engine by memory

C. Ensure to establish and maintain a zero sideslip

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Failure to Plan for Engine Failure During Flight**
   A. Be prepared & plan ahead!
      i. Rehearsing the steps you will take in the case of an emergency greatly enhances your situational awareness in the case one actually occurs
      ii. It also helps to prevent startle response
         a. Startle response is a largely unconscious defensive response to sudden or threatening stimuli, such as sudden noise or sharp movement, and is associated with negative affect. Usually the onset of the startle response is a startle reflex reaction.
         b. A knee-jerk reaction is not conducive to handling an emergency. Be prepared and plan your actions in the case of an engine failure
      iii. Know altitudes required en-route, single engine performance capabilities, as well as divert options
         a. Be prepared
2. **Collision Hazards, to Include Aircraft, Terrain, Obstacles and Wires**
   A. Collision Avoidance
      i. Operation Lights On
         a. A voluntary FAA safety program to enhance the see and avoid concept
         b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in

conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)

ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
        - If they are different categories:
            a A balloon has the right of way over any other category
            b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
            c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
            d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
    c. Approaching Head-on
        - Each pilot shall alter course to the right
    d. Overtaking
        - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear
    e. Landing
        - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
            a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
        - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
            a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
    a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
        - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
        - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
    a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
    b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
        - This is also more applicable to cruise, but can be used while the pattern, if necessary
    c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Scanning

    a. Use a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field
        - Each movement should not exceed 10 degrees, and each area should be observed for at least one second to enable detection

B. Terrain
  i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
    a. Study sectionals and terminal area charts
    b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
    c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.
  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
        - Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain
    b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance
  i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL
    a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing
    b. Become familiar with any obstacles on the approach and departure path
    c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)
    d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen
    e. NOTAMs are issued on lighted structures experiencing light outages
  ii. Antenna Towers
    a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see
        - Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure
  iii. Overhead Wires
    a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)
    b. These wires and lines may or may not be lighted
    c. Be extremely vigilant on takeoff and landing

3. Improper Aircraft Configuration

A. Recognize the Engine Failure and Maintain Directional Control (establish a zero-sideslip)
  i. An improper response can result in a loss of directional control. The aircraft is going to yaw toward the dead engine, not countering the with rudder and aileron could result in a loss of control or simply a roll toward the dead engine until impacting the ground
  ii. The zero sideslip provides the least amount of drag (coordinated flight) to provide the best aircraft climb performance
    a. This is necessary since half of the aircraft's power is gone

B. Full Power
  i. Since one engine is inoperative, maximize the power on the remaining engine

a. Depending on atmospheric conditions and the aircraft's weight/configuration, not using full power could in the best case, result in a lower rate of climb than if the engine were at full power, or in the worst case, an inability to climb at all

C. Reduce Drag – Gear and Flaps Up
   i. Similar to using max power, reducing drag assists in the aircraft's ability to climb and accelerate
   ii. Leaving the gear or flaps hanging will inhibit the aircraft's ability to climb. Performance will be degraded

D. Identify

E. Verify

F. Fix or Feather
   i. Feathering the engine eliminates a large amount of drag. A failure to feather the engine can greatly inhibit the aircraft's climb performance

4. Low Altitude Maneuvering

A. Low Altitude Maneuvering
   i. A small problem at high altitude can quickly become a big problem at a low altitude
      a. There is considerably less time to handle any issues at a low altitude
      b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
         - Precise flying (zero sideslip, on speed and altitude) results in better aircraft performance (less drag, and higher rates of climb)
      c. This is especially important with a failed engine: distractions can lead to a loss of control or airspeed falling below V_{MC}
   ii. Be aware of, and avoid obstructions on and around the airfield
      a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
   iii. Plan ahead to avoid obstacles

B. Low Altitude Stall/Spin
   i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination (zero sideslip), and airspeed at low altitudes. Do Not go below V_{MC}!
      a. Airspeed
         - Maintaining a stabilized climb or approach is essential to safety. Airspeed is a big part of being stabilized.
            a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
               1. V_{MC} will only make the situation worse, potentially unrecoverable (if the aircraft is stalled and below V_{MC} at a low altitude)
         - At the first indication of a stall or loss of control, perform the V_{MC} recovery
            a Take the power to idle, lower the nose to regain airspeed, and reintroduce power at a safe speed – climb back to altitude and setup for another approach

C. CFIT (Controlled Flight into Terrain)
   i. AC 61-134: General Aviation CFIT Awareness
      a. This becomes even more of an issue in the case of an emergency approach and landing
         - In the case the aircraft does not have power the pilot must be vigilant and aware of the surrounding terrain in order to avoid a situation in which he or she cannot maneuver away from terrain
         - Emergencies are huge distractions. Divide attention between the emergency situation and flying the aircraft. Do not become to consumed by the situation to allow the aircraft to fly into terrain
   ii. The solution to combating CFIT accidents starts on the ground

a. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range

iii. Recommendations:
a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
b. Know and fly above minimum published safe altitudes.
- VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.

c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
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 outside the United States or 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.

5. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
i. Fly first!
a. Aviate, Navigate, Communicate

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Situational awareness is extremely important when handling an engine failure, and a loss of situational awareness can lead to unsafe situations
i. Be aware of the aircraft, its airspeed, configuration, pitch attitude, etc.
a. Take breaks between the emergency checklist or memory items steps to fly the aircraft

ii. Know the plan of action in the case of an engine failure or an emergency at different points
iii. Always be aware of other traffic. Build a 3d picture based on what you can see, and what you hear on the radio
iv. Maintain situational awareness

C. Task Management
i. Your first job is always to control the aircraft. In this case, that means safely piloting the aircraft through the engine failure. Maintain directional control, ensure a safe airspeed, configure the aircraft appropriately and continuing with the necessary memory items and checklists
a. Once the emergency is handled, then move to additional tasks such as additional checklists and communicating with ATC

ii. Safety is your number one priority
a. Understand what tasks need to be accomplished and when. Prioritize them based on importance and time available.
b. Checklists are extremely helpful in properly managing tasks

SKILLS

The applicant demonstrates the ability to:

1. Recognize an engine failure, maintain control, use manufacturer's memory item procedures, and utilize appropriate emergency procedures.
2. Set the engine controls, identify and verify the inoperative engine, and feather appropriate propeller.
3. Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain the best performance, and trim as required.
4. Attempt to determine and resolve the reason for the engine failure.
5. Secure the inoperative engine and monitor the operating engine and make necessary adjustments.
6. Restart the inoperative engine using manufacturer's restart procedures.
7. Maintain altitude ±100 feet or minimum sink as appropriate and heading ±10°.
8. Complete the appropriate checklist.

X.B. V_{MC} Demonstration

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. Factors Affecting V_{MC} and how V_{MC} Differs from Stall Speed (V_S)

A. V_{MC}
   i. In aircraft certification, V_{MC} is the sea level calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5°
   ii. V_{MC} and the Loss of Control
      a. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
         - The rudder cannot maintain control and the plane yaws in the direction of the inoperative engine
      b. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
   iii. V_{MC} is not a fixed airspeed under all conditions
      a. It is only a fixed airspeed for the very specific set of circumstances under which it was tested during aircraft certification
      b. V_{MC} varies with a variety of factors

B. Factors
   i. Critical Engine Wind Milling
      a. V_{MC} increases with increased drag on the inoperative engine
         - V_{MC} is therefore the highest when the critical engine prop is wind milling at the low pitch, high rpm blade angle
   ii. Maximum Available Takeoff Power
      a. V_{MC} increases as power is increased on the operating engine
   iii. Density Altitude
      a. V_{MC} decreases with increases in altitude or a decrease in density
         - Due to the lessened thrust at higher density altitudes, less yaw is experienced in relation to P-Factor
   iv. Most Unfavorable Weight
      a. V_{MC} is increased as weight is reduced
         - A heavier plane is a more stable and controllable plane
         - Also, the weight of the airplane assists in establishing and maintaining a zero-side slip
   v. Most Unfavorable CG
      a. V_{MC} increases as the CG is moved aft
         - The moment of the rudder arm is reduced, and therefore its effectivity is reduced
         - AND, the moment arm of the propeller blade is increased, aggravating asymmetrical thrust
   vi. Landing Gear Retracted
      a. V_{MC} increases when the landing gear is retracted
         - Extended gear aids in directional stability, which tends to decrease V_{MC}

vii. Flaps in the takeoff Position
    a. Flaps in the takeoff position decreases V_{MC}
    b. Creates extra drag on the operating engine
        - This reduces the tendency to yaw toward the inoperative engine

viii. Cowl Flaps in the T/O position
    a. Open cowl flaps will produce more drag on the operative engine, therefore decreasing V_{MC}

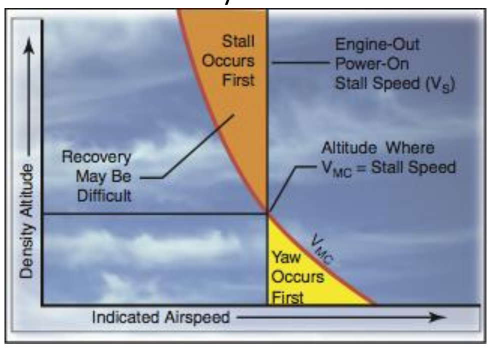
ix. Airplane Trimmed for Takeoff
    a. This varies between aircraft due to different T-tail, low tail, type of elevator and trim setting

x. Airplane Airborne and Out of Ground Effect
    a. If in Ground Effect, as the airplane is banked into the operative engine it would generate more lift on the lowered wing, increasing the rolling tendency toward the inoperative engine (V_{MC} increases)

xi. Maximum 5° of Bank
    a. V_{MC} is highly sensitive to bank angle
        - To prevent claims of unrealistically low speeds, the bank into the operating engine is limited
    b. The horizontal component of lift from the bank assists the rudder in counteracting the asymmetrical thrust
    c. The bank angle works in the manufacturer's favor, lowering V_{MC}
    d. V_{MC} is reduced significantly with increases in bank and increases significantly with decreases
        - Tests have shown that V_{MC} may increase > 3 knots for each degree of bank less than 5°

Factor	Control	V_{MC}	Performance
CG – Forward	Increases	Decreases (Good)	Decreases
CG – Aft	Decreases	Increases (Bad)	Increases
Weight – Increase	Increases	Decreases (Good)	Decreases
Density Altitude – High	Increases	Decreases (Good)	Decreases
Gear – Up	Decreases	Increases (Bad)	Increases
Flaps – Up	Decreases	Increases (Bad)	Increase
Wind Milling Prop	Decreases	Increases (Bad)	Decreases
Max T/O Power	Depends	Increases (Bad)	Increases
Cowl Flaps Open	Increases (?)	Decreases (Good)	Decreases
Bank Angle (Up to 5°)	Increases	Decreases (Good)	Increases
Airborne/Out of GE	Decreases	Increases (Bad)	Decreases
Trimmed for T/O	Could go either way →		

C. V_{MC} and Stall Speed
   i. V_{MC} decreases with altitude, while stall speed remains the same
      a. This causes the margin between stall speed and V_{MC} to decrease with altitude
      b. There is an altitude where V_{MC} and V_S are the same. Above that altitude, V_{MC} will occur after a stall
         - The altitude where V_{MC}=V_S and above, is extremely dangerous; recovery can be difficult
   ii. Although the pilot does not have the ability to maintain directional control of the aircraft at speeds



below V_{MC} with an engine failed, the aircraft will still fly. Whereas in a stall, the wings are no longer producing lift, the wings are still generating lift in a V_{MC} demo, but the thrust produced by the operating engine is too strong for the rudder to overcome

2. V_{MC} (Red Line), V_{YSE} (Blue Line), and V_{SSE} (Safe Single-Engine Speed)

A. V_{MC}
   i. Minimum control speed with the critical engine inoperative under a very specific set of circumstances (above) outline in 14 CFR Part 23, Airworthiness Standards. Marked with a red radial line on most airspeed indicators
      a. Under the regulations currently in effect, the test pilot must be able to:
         - Stop the turn that results when the critical engine is suddenly made inoperative within 20-degrees of the original heading, using maximum rudder deflection and a maximum of 5-degrees of bank, and
         - Thereafter, maintain straight flight with not more than 5-degrees of bank
      b. There is no requirement that the aircraft be capable of climbing at this speed. V_{MC} only addresses directional control

B. V_{YSE}
   i. Best rate-of-climb speed with one engine inoperative. Marked with a blue line on most airspeed indicators. Above the single engine absolute ceiling, V_{YSE} yields the minimum rate of sink
   ii. Whereas VMC addresses directional control, V_{YSE} addresses the aircraft's ability to climb (or maintain the minimum sink) with an inoperative engine
      a. It is very important the pilot monitors airspeed to avoid slowing to V_{MC}

C. V_{SSE}
   i. Safe, intentional one-engine inoperative speed. Formally defined in 14 CFR Part 23, Airworthiness Standards, and required to be established and published in the AFM/POH. It is the minimum speed to intentionally render the critical engine inoperative

3. The Cause of Loss of Directional Control at Airspeeds less than V_{MC}

A. Control is lost when the moment of the thrust arm of the operating engine exceeds that of the rudder
   i. The rudder cannot maintain control and the plane yaws in the direction of the inoperative engine

B. Loss of control is indicated when full rudder is applied into the operating engine and the airplane continues to yaw toward the inoperative engine
   i. It can be seen visually with a visual reference point or on the heading indicator

C. The proper pitch and bank attitude should be maintained in order to obtain an accurate V_{MC} speed
    i. Without the zero-sideslip condition, V_{MC} will increase and directional control may be lost early

4. Proper Procedures for Maneuver Entry and Safe Recovery

A. Maneuver Entry
    i. Choose a visual reference point to maintain during the procedure
    ii. Stabilize the aircraft approximately 10 knots above V_{SSE} and establish a single engine zero sideslip configuration
        a. Gently reduce power on the operating engine (add rudder to maintain heading)
            - Use slow power movements (fast movements are hard to control)
    iii. Brief the rest of the maneuver
        a. "I will pitch up at a rate to realize a decrease of 1 knot per second. At the first indication of a loss of directional control or a stall, I will reduce power on the operating engine and lower the nose."
    iv. As airspeed bleeds at approximately 1 knot per second, increase rudder to maintain directional control
        a. As airspeed decreases, the rudder becomes less effective while the engine continues producing the same amount of thrust (yaw), therefore rudder must be increased to maintain your reference point
        b. When the rudder is fully deflected, you are at V_{MC}
            - Any slower than this speed will result in a loss of directional control (the rudder will not be able to control the yaw caused by the critical engine being inoperative)
            - Use a visual reference to maintain heading, keep your eyes outside
                a Recognize the loss of control - Keep an eye outside, as soon as the aircraft uncontrollably yaws even 1° start to recover

B. Recovery
    i. The moment uncontrollable yaw or any symptom associated with a stall is recognized, recover
    ii. The operating engine throttle should be retarded as pitch attitude is decreased
        a. Retarding the throttle will tend to fix the yawing problem (the thrust moment is reduced)
        b. Decreasing pitch increases airspeed, making the rudder more effective
        c. By reducing power, you are decreasing the amount of yaw the rudder has to overcome and by pitching forward you are increasing the amount of force the rudder can produce
    iii. Recovery is made to straight flight at V_{YSE} with the operating engine throttle reintroduced
    iv. Once complete, smoothly scissor the power levers back together

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Improper Aircraft Configuration

A. The configuration specified, for the most part, represents a worst-case scenario: an engine failure just after takeoff with the gear retracted (committed to flying), maximum power, and a failure of the critical engine
    i. The worst-case scenario equates to a high V_{MC}
    ii. Being able to handle the worst-case scenario allows the pilot to handle all other cases

2. Maneuvering with One Engine Inoperative

A. Recognize engine failure and maintain control
    i. The easiest way to recognize an engine failure is visually (if in V_{MC})
        a. The pilot will recognize an uncommanded yaw in the direction of the dead engine

b. Visual recognition allows for better control, don't stare at the engine instruments, fly the plane
c. If in IMC, the engine failure will be recognized on the instruments, the aircraft will yaw toward the dead engine, the nose will drop, engine gauges will indicate a failure

ii. When an engine fails use rudder and aileron to maintain directional control
a. Establish a zero-sideslip configuration by adding approximately 2-3° of bank to counteract the roll and maintaining heading visually with rudder pressure (the aircraft will almost fall into a sideslip)
- After a couple degrees of bank are established and rudder pressure is set to maintain heading double check the zero sideslip on the instruments and make changes needed
  - a A zero sideslip will vary based on the aircraft flown, but 1-3° bank toward the operating engine and ½ ball deflection (on the turn coordinator) toward the operating engine should be close
- Additional bank or too little bank will create excess drag on the airframe (since it is no longer coordinated), thus reducing performance

B. Flying on One Engine
i. Approximately 80% power will maintain a comfortable airspeed in level flight
a. Power will need to be adjusted based on weight/atmospheric conditions
ii. Trim the aircraft for straight and level flight and use rudder trim (if available) to assist in maintaining a zero sideslip
a. Remove rudder trim prior to landing
- As you reduce power during the landing the aircraft will yaw in the direction of the rudder trim if it is left in
  - a This could result in a side-loaded landing, or a landing off of the prepared surface and can be potentially dangerous

iii. Maintain level flight at speeds above V_{YSE}, if possible
a. If impossible, maintain V_{YSE}
- If unable to hold altitude, the aircraft will descend until an altitude is reached that can be maintained
  - a Approximately the single engine service ceiling
- Speeds other than V_{YSE} will result in degraded performance
  - a If you need to climb, maintain V_{YSE}
  - b In straight and level maintain V_{YSE} or faster

3. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions
i. Fly first!
a. Aviate, Navigate, Communicate
ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Loss of Situational Awareness
i. Loss of Control
a. A failure to maintain situational awareness while near or below V_{MC} can result in a loss of control. A continued loss of situational awareness can result in the inability to recover from the situation (not reducing power, and/or not lowering the nose)
ii. Use the V_{MC} recovery procedure anytime the aircraft is approaching V_{MC} and any sign of loss of control or a stall is experienced
a. Failing to do this can be catastrophic

C. Task Management
   i. Your first job is always to control the aircraft. In this case, this means understanding what V_{MC} is and how to properly and safely recover from speeds below V_{MC} with a failed engine
   ii. Once the aircraft is safely under control, then proceed to additional tasks

SKILLS

The applicant demonstrates the ability to:

1. Configure the airplane in accordance with the manufacturer's recommendations, in the absence of the manufacturer's recommendations, then at V_{SSE}/V_{YSE}, as appropriate:
    - Landing gear retracted
    - Flaps set for takeoff
    - Cowl flaps set for takeoff
    - Trim set for takeoff
    - Propellers set for high RPM
    - Power on critical engine reduce to idle and wind milling
    - Power on operating engine set to takeoff or maximum available power
2. Establish a single-engine climb attitude with the airspeed at approximately 10 knots above V_{SSE}.
3. Establish a bank angle not to exceed 5° toward the operating engine, as required for best performance and controllability.
4. Increase the pitch attitude slowly to reduce the airspeed at approximately 1 knot per second while applying rudder pressure to maintain directional control until full rudder is applied.
5. Recognize indications of loss of directional control, stall warning, or buffet.
6. Recover promptly by simultaneously reducing power sufficiently on the operating engine while decreasing the angle of attack as necessary to regain airspeed and directional control. Recovery should not be attempted by increasing the power on the simulated failed engine.
7. Recover within 20° of the entry heading.
8. Advance power smoothly on the operating engine and accelerate to V_{SSE}/V_{YSE}, as appropriate, +10/-5 knots, during the recovery.

X.C. Engine Failure During Flight by Reference to Instruments

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Instrument Procedures used with One Engine Inoperative**
   - A. Instrument Flight 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
   - B. Maneuvering with One Engine Inoperative
     - i. Recognize the engine failure and maintain control
       - a. When an engine fails use rudder and aileron to maintain directional control
         - Establish a zero-sideslip configuration by adding approximately 1-3° of bank to counteract the roll, and rudder in order to achieve a ½ ball deflection toward the operating engine
         - After a couple degrees of bank are established and rudder pressure is set to maintain heading double check the zero sideslip on the instruments and make changes needed
           - a A zero sideslip will vary based on the aircraft flown, but 1-3° bank toward the operating engine and ½ ball deflection (on the turn coordinator) toward the operating engine should be close
     - ii. This is done strictly by instruments
   - C. Zero Side Slip by Instruments

Pitch + Power = Desired Performance
Nose slightly high + Zero Sideslip + 80% power = SE Straight and Level

Pitch		Bank	
A/I	4° Nose High	A/I	1-3° Bank
Alt	Constant	DG	Constant
VSI	0	Compass	Constant
A/S	V_{yse} or higher	T/C	½ ball deflection

     - i. Establish **-** Use the attitude indicator to establish a wings level, nose on the horizon attitude adjusting power as needed
     - ii. Trim – Trim to relieve the control pressures
     - iii. Crosscheck
     - iv. Adjust – Correct any performance errors as necessary and re-trim the aircraft, then crosscheck again
   - D. Turning Flight

Pitch + Power = Desired Performance
Nose slightly high + Zero Sideslip + 80% Power = SE Level Turns

Pitch		Bank	
A/I	5-6° Nose High	A/I	10° Bank
Alt	Constant	DG	Turning
VSI	0	Compass	Turning
A/S	V_{yse} or higher	T/C	½ ball deflection

i. Continue the scan
   a. Add bank as necessary
      - Keep "coordinated" (zero sideslip)
   b. Increase pitch attitude to maintain altitude
ii. Establish, Trim, Crosscheck, Adjust
   a. Note the small bank angles used (just 10 degrees), excessive bank can be disorienting and result in a loss of control or a difficulty maintaining control

E. Managing the Engine Failure
   i. Use the same steps as an engine failure in visual conditions:
      a. Full Power
      b. Reduce Drag
      c. Identify
      d. Verify
      e. Fix or Feather
      f. Restart the Inoperative Engine (if required and safe)
   ii. Pay even more attention to your instrument scan/flying the aircraft
      a. Between every step, stop and check for zero sideslip, heading, altitude, engine indications

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Identify the Inoperative Engine

A. Reduced Performance
   i. Uncoordinated Flight and Excessive Drag
      a. Identifying and verifying the inoperative engine allows the pilot to establish a zero sideslip (coordinated flight). Without a zero sideslip, the aircraft is uncoordinated, drag is increased and performance is decreased (potentially significantly)

B. Loss of Control
   i. Applying rudder and/or aileron in the direction of the failed engine can lead to excessive yaw and roll and a loss of control
   ii. Additionally, an inability or failure to identify and verify the inoperative engine could result in over controlling the aircraft. This could lead to various scenarios, the worst likely being a single engine stall and/or spin

C. Loss of Both Engines
   i. If the pilot were to attempt to feather and secure the engine without first identifying the inoperative engine it is very possible he or she will feather and secure the incorrect engine and be left with no power

D. Take the time to maintain aircraft control, and positively identify, and verify the inoperative engine

2. **Inability to Climb or Maintain Altitude with an Inoperative Engine**
   A. Aircraft performance (the ability of the aircraft to climb) is drastically reduced after an engine failure. Although power is reduced by ½ (1 of the 2 engines is inoperative), performance can be reduced by 80% - 90%
      i. Performance, or the aircraft's ability to climb, is based on excess horsepower.
      ii. Say, for example (and these numbers are for demonstration purposes only), a twin aircraft generates 170 horsepower per engine (340 horsepower total) and uses 130 horsepower to maintain straight and level flight at a certain airspeed and altitude. In this situation, the aircraft has 210 excess horsepower (this is the aircraft's ability to climb, a representation of performance).
      iii. When an engine fails, the total power is reduced from 340 horsepower to 170 horsepower (50% power reduction), but the excess power (the difference between the power required to maintain level flight and the power available) has decreased from 210 horsepower to 40 hp. This is a loss of 170 horsepower, or about 80% of the aircraft's performance.
         a. The aircraft still requires 130 horsepower to maintain level flight, but now only has 170 horsepower available. Therefore, the excess horsepower is now only 40.
      iv. Performance is maximized by following the engine failure procedures and ensuring max power, a zero-sideslip, gear and flaps up, and a feathered propeller. A failure to take care of any of these factors requires more horsepower from the aircraft, thus reducing the single-engine performance.
   B. Be aware of altitudes required along the route of flight and ensure the aircraft's single engine performance can meet the altitudes required
      i. Use the performance charts in the POH for single engine service ceiling, climb rate, etc.
   C. In the case the aircraft cannot maintain altitude, execute an emergency landing at the most suitable place
3. **Low Altitude Maneuvering**
   A. Low Altitude Maneuvering
      i. A small problem at high altitude can quickly become a big problem at a low altitude
         a. There is considerably less time to handle any issues at a low altitude
         b. Therefore, avoid distractions, maintain situational awareness, and fly precisely
            - Precise flying (zero sideslip, on speed and altitude) results in better aircraft performance (less drag, and higher rates of climb)
         c. This is especially important with a failed engine: distractions can lead to a loss of control or airspeed falling below V_{MC}
      ii. Be aware of, and avoid obstructions on and around the airfield
         a. Quick, panicked maneuvers at the relatively slow airspeeds associated with takeoff and landing can result in a stall or loss of control close to the ground
      iii. Plan ahead to avoid obstacles
   B. Low Altitude Stall/Spin
      i. A low altitude stall or spin can leave little to no recovery time. ALWAYS maintain coordination (zero sideslip), and airspeed at low altitudes. Do Not go below V_{MC}!
         a. Airspeed
            - Maintaining a stabilized climb or approach is essential to safety. Airspeed is a big part of being stabilized.
               a Keep airspeed in your crosscheck since there may not be enough altitude to recover from a stall at low altitudes
                  1. V_{MC} will only make the situation worse, potentially unrecoverable (if the aircraft is stalled and below V_{MC} at a low altitude)
            - At the first indication of a stall or loss of control, perform the V_{MC} recovery

a. Take the power to idle, lower the nose to regain airspeed, and reintroduce power at a safe speed – climb back to altitude and setup for another approach

C. CFIT (Controlled Flight into Terrain)
   i. [AC 61-134](): General Aviation CFIT Awareness
      a. This becomes even more of an issue in the case of an emergency
         - In the case the aircraft does not have power the pilot must be vigilant and aware of the surrounding terrain in order to avoid a situation in which he or she cannot maneuver away from terrain
         - Emergencies are huge distractions. Divide attention between the emergency situation and flying the aircraft. Do not become to consumed by the situation to allow the aircraft to fly into terrain
   ii. The solution to combating CFIT accidents starts on the ground
      a. Prepare properly to safely execute the maneuvers required throughout the entire flight. How the flight is planned and handled determines to a great extent the safety of the flight
      b. Common themes to preventing CFIT include proper planning, good decision making, and being able to safely operate the aircraft throughout its entire operating range
   iii. Recommendations:
      a. Non-instrument rated VFR pilots should not attempt to fly in IMC.
      b. Know and fly above minimum published safe altitudes.
         - VFR: Fly a minimum of 1,000 feet above the highest terrain in your immediate operating area in non-mountainous areas. Fly a minimum of 2,000 feet in mountainous areas.
      c. If IFR, fly published procedures. Fly the full published procedure at night, during minimum weather conditions, or operating at an unfamiliar airport.
      d. Verify proper altitude, especially at night or over water, through use of a correctly set altimeter.
      e. Verify all ATC clearances. Question an ATC clearance that assigns a heading and/or altitude that, based upon your situational awareness, places the aircraft in a CFIT environment.
      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 outside the United States or 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.

4. Distractions, Loss of Situational Awareness, and /or Improper Task Management

A. Distractions
   i. Fly first!
      a. Aviate, Navigate, Communicate
   ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.
      a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Loss of Situational Awareness
   i. Divide attention between flying the aircraft and navigating (this is especially important without outside references – it is much easier to unknowingly lose control in IMC)
      a. Focusing too much attention on either one of these can result in the other being neglected
      b. Maintain a zero sideslip to maintain altitude and coordination
         - This is especially applicable at or near either of the service ceilings

c. Trim the aircraft to reduce the pilot's workload, if approved in the POH, use the autopilot
d. An emergency situation creates considerably more work and stress (especially single pilot), use the tools available to reduce your workload

ii. A loss of situational awareness is considerably more difficult to regain in a situation such as this
   a. A loss of situational awareness can lead to:
      - Getting lost – over focus on flying single engine/a neglect of where the aircraft is going
      - Loss of Control – over focus on navigating to the alternate/a neglect of the aircraft
         a Loss of the zero sideslip, a reduction in speed below V_{MC}
      - Missed Checklists/Emergency Procedures – Focusing entirely on the flying and navigating/a neglect of normal and emergency checklists
      - Lack of Communication – the distractions associated with an emergency can take the pilot's attention away from communicating
         a This can be a safety issue, but also eliminates a huge helping hand from ATC

C. Task Management
   i. Aviate, Navigate, Communicate
      a. The first step is always to fly the aircraft, especially in the case of an engine failure
      b. While taking care of checklists and communicating with ATC stop every few seconds to verify the aircraft is still in a zero sideslip, on heading, altitude, etc.
         - The checklist will get done, fly the aircraft, don't lose control - especially close to the ground

5. Fuel Management During Single-Engine Operation

A. Fuel crossfeed is a method of getting fuel from a tank on one side of the aircraft to an operating engine on the other and is used for extended single-engine operations
   i. If a suitable airport is close at hand, there is no need to consider crossfeed
   ii. If prolonged flight on a single-engine is inevitable due to airport non-availability, then crossfeed allows use of fuel that would otherwise be unavailable to the operating engine. It also permits the pilot to balance the fuel consumption to avoid an out-of-balance wing heaviness

B. POH procedures for crossfeed vary widely
   i. Thorough fuel system knowledge is essential if crossfeed is to be conducted
   ii. Fuel selector positions and fuel boost pump usage differ greatly among aircraft

C. Prior to landing, crossfeed should be terminated and the operating engine returned to its main tank fuel supply

SKILLS

The applicant demonstrates the ability to:

1. Promptly recognize an engine failure and maintain positive aircraft control.
2. Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine)
3. Establish the best engine-inoperative airspeed and trim the aircraft.
4. Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
5. Verify the prescribed checklist procedures normally used for securing the inoperative engine.
6. Attempt to determine and resolve the reason for the engine failure.
7. Monitor engine functions and make the necessary adjustments.

8. Maintain the specified altitude within ±100 feet, or minimum sink rate if applicable, airspeed ±10 knots, and the specified heading ±10°.
9. Assess the airplane's performance capability and decide an appropriate action to ensure a safe landing.
10. Avoid loss of airplane control, or attempted flight contrary to the engine-inoperative operating limitations of the airplane.
11. Demonstrate SRM.

X.D. Instrument Approach and Landing with an Inop Engine by Reference to Instruments

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Flying Light Twins Safely (FAA-P-8740-066), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Instrument Approach Procedures used with One Engine Inoperative**

These speeds and power settings in this lesson were recommendations for a DA42
Use the POH for airspeeds and power settings appropriate to the aircraft you're flying

- A. Manage the Engine Failure
  - i. Recognize engine failure and maintain control
    - a. When an engine fails use rudder and aileron to maintain directional control
      - a Establish a zero-sideslip configuration by adding approximately 1-3° of bank to counteract the roll and rudder in order to achieve a ½ ball deflection toward the operating engine
    - b. This is done strictly by instruments
  - ii. Use the same steps as an engine failure in visual conditions:
    - a. Full Power
    - b. Reduce Drag
    - c. Identify
    - d. Verify
    - e. Feather
  - iii. Pay even more attention to your instrument scan/flying the aircraft
    - a. Between every step stop and check for zero sideslip, heading, altitude, engine indications
- B. Brief the Approach
  - i. Normal approach brief
  - ii. Speeds and aircraft configuration will change but the approach itself stays the same
- C. Precision Approach
  - i. Configuration
    - a. Maintain a zero sideslip
      - As power is reduced on the approach, rudder should be reduced as well
      - Scan will have to be increased to maintain scan as well as glideslope/localizer
    - b. Procedure Turn (inbound/Outbound), Localizer Intercept
      - Airspeed: 100 KIAS
      - Power: 80%
    - c. ½ Dot Below Glide Slope
      - Airspeed: Decelerating to 90 KIAS
      - Power: 65%
      - Flaps: As necessary
    - d. Glide Slope Intercept (FAF)
      - Airspeed: Single Engine Approach (no slower than V_{yse})
      - Power: Approximately 65%
      - Pitch: Approximately 5° Nose Down
  - ii. Checklist Items

a. Pre-Landing Checklist
b. Arriving at any Fix (5 T's)
  - Turn
  - Time
  - Twist
  - Throttle
  - Talk

D. Non-Precision Approach
  i. Configuration
    a. Maintain a zero sideslip
      - As power is reduced on the approach, rudder should be reduced as well
      - Scan will have to be increased to maintain scan as well as course and monitor step downs
    b. Procedure Turn (inbound/Outbound), Localizer Intercept
      - Airspeed: 100 KIAS
      - Power: 80%
    c. 1 nm from FAF
      - Airspeed: Decelerating to 90 KIAS
      - Power: 65%
      - Flaps: As necessary
    d. FAF
      - Airspeed: Single Engine Approach (no slower than V_{yse})
      - Power: Approximately 55%
      - Pitch: Approximately 6° Nose Down
        a Descend slightly faster than Precision Approach in order to reach MDA prior to the missed approach point
          1. Provides time to find and then descend to the runway
    e. MDA/Step Down
      - Level off without going below MDA/Step down altitude
        a Approximately 80% power, do not slow below V_{yse}
        b With increased power comes increased rudder, maintain a zero sideslip
  ii. Checklist Items
    a. Pre-Landing Checklist
    b. Arriving at any Fix (5 T's)
      - Turn
      - Time
      - Twist
      - Throttle
      - Talk

E. Maintenance of Altitude, Airspeed, and Track
  i. Establish, Trim, Crosscheck, Adjust
    a. Keep the zero sideslip while focusing on the approach
  ii. Keep the scan moving, include everything in your scan
    a. Occasionally include the approach chart in the scan
  iii. Always ask, "What am I doing next?"
    a. Stay ahead of altitudes, airspeed, track
    b. Use the 5 Ts at every waypoint
      - Turn, Time, Twist, Throttle, Talk

        a. Will I need any of these?
  - iv. Keep the localizer needle centered
    - a. Be proactive in maintaining the localizer course
      - Make adjustments for wind
        - a Use the heading bug to bug the heading that will maintain the desired course
        - b Make adjustments to the right/left of the heading bug to correct for course deviations
  - v. When the glide slope centers, pitch down approximately 5° and maintain a centered glide slope indication
    - a. Be proactive in maintaining glide slope
      - If the ball starts to move up/down make small adjustments immediately to arrest the movement
      - As groundspeed increases, rate of descent must increase as well
      - As groundspeed decreases, rate of descent must decrease as well
- F. Appropriate Rate of Descent
  - i. A descent rate of greater than 1,000 FPM is unacceptable during the final stages of an approach
    - a. This is due to human perceptual limitation independent of the type of airplane
    - b. Especially applicable in single engine situation, maintain a controlled, stabilized approach
  - ii. A descent rate should be used that will ensure reaching the decision altitude at a distance from the threshold that will allow landing in the touchdown zone
    - a. The glide slope will ensure you maintain the appropriate rate of descent, follow it
- G. Landing
  - i. Perform a visual landing as previously discussed/taught

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Failure to Plan for Engine Failure During Approach and Landing
- A. Approach and Landing Briefing
  - i. Prior to the approach, brief the intended approach and landing and contingencies in the case of emergencies such as an engine failure
  - ii. Know how you will handle the failure, how you will fly the aircraft and the intended approach
- B. Plan Ahead! This applies both to takeoff and landing.
  - i. Rehearsing the steps you will take in the case of an emergency greatly enhances your situational awareness in the case one actually occurs
  - ii. It also helps to prevent startle response
    - a. Startle response is a largely unconscious defensive response to sudden or threatening stimuli, such as sudden noise or sharp movement, and is associated with negative affect. Usually the onset of the startle response is a startle reflex reaction.
    - b. A knee-jerk reaction is not conducive to handling an emergency. Be prepared and plan your actions in the case of an engine failure

2. Distractions, Loss of Situational Awareness, and /or Improper Task Management
- A. Distractions
  - i. Fly first!
    - a. Aviate, Navigate, Communicate
  - ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

a. Especially during an emergency situation, like an engine failure, distractions can be very hazardous. Eliminate any distractions and fly the aircraft

B. Loss of Situational Awareness
   i. Divide attention between flying the aircraft, navigating, and communicating with ATC
      a. This is especially important without outside references – it is much easier to unknowingly lose control in IMC
      b. Focusing too much attention on any one task can result in the others being neglected
      c. Maintain a zero sideslip to maintain altitude and coordination
         - This is especially applicable at or near the service ceilings
         - Trim the aircraft to reduce the pilot's workload, and if approved in the POH, use the autopilot
      d. An emergency situation creates considerably more work and stress (especially single pilot), use the tools available to reduce your workload
         - Automation, GPS, ATC, etc.
   ii. A loss of situational awareness is considerably more difficult to regain in a situation such as this
      a. A loss of situational awareness can lead to:
         - Getting lost – over focus on flying single engine/a neglect of where the aircraft is going
         - Loss of Control – over focus on navigating to the alternate/a neglect of the aircraft
            a Loss of the zero sideslip, a reduction in speed below V_{MC}
         - Missed Checklists/Emergency Procedures – Focusing entirely on the flying and navigating/a neglect of normal and emergency checklists
         - Lack of Communication – the distractions associated with an emergency can take the pilot's attention away from communicating
            a This can be a safety issue, and eliminates ATC as a resource
            b When able communicate with ATC (declare an emergency, ask for assistance/vectors/whatever else you might need)

C. Task Management
   i. Aviate, Navigate, Communicate
      a. The first step is always to fly the aircraft, especially in the case of an engine failure
      b. While taking care of checklists and communicating with ATC stop every few seconds to verify the aircraft is still in a zero sideslip, on heading, altitude, etc.
         - The checklist will get done, fly the aircraft, don't lose control - especially close to the ground

3. Single-Engine Performance

A. Aircraft performance (the ability of the aircraft to climb) is drastically reduced after an engine failure. Although power is reduced by ½ (1 of the 2 engines is inoperative), performance can be reduced by 80% - 90%
   i. Performance, or the aircraft's ability to climb, is based on excess horsepower.
   ii. Say, for example (and these numbers are for demonstration purposes only), a twin aircraft generates 170 horsepower per engine (340 horsepower total) and uses 130 horsepower to maintain straight and level flight at a certain airspeed and altitude. In this situation, the aircraft has 210 excess horsepower (this is the aircraft's ability to climb, a representation of performance).
   iii. When an engine fails, the total power is reduced from 340 horsepower to 170 horsepower (50% power reduction), but the excess power (the difference between the power required to maintain level flight and the power available) has decreased from 210 horsepower to 40 hp. This is a loss of 170 horsepower, or about 80% of the aircraft's performance.
      a. The aircraft still requires 130 horsepower to maintain level flight, but now only has 170 horsepower available. Therefore, the excess horsepower is now only 40.

B. Performance is maximized by following the engine failure procedures and ensuring max power, a zero-sideslip, gear and flaps up, and a feathered propeller. A failure to take care of any of these factors requires more horsepower from the aircraft, thus reducing the single-engine performance.

SKILLS

The applicant demonstrates the ability to:

1. Promptly recognize engine failure and maintain positive airplane control. Set the engine controls, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine. (Evaluator should then establish zero thrust on the inoperative engine).
2. Use flight controls in the proper combination as recommended by the manufacturer, or as required to maintain best performance, and trim as required.
3. Follow the manufacturer's recommended emergency procedures.
4. Monitor the operating engine and make adjustments as necessary.
5. Request and follow an actual or a simulated ATC clearance for an instrument approach.
6. Maintain altitude ±100 feet or minimum sink rate if applicable, airspeed ±10 knots, and selected heading ±10°.
7. Establish a rate of descent that will ensure arrival at the MDA or DH/DA with the airplane in a position from which a descent to a landing on the intended runway can be made, either straight in or circling as appropriate.
8. On final approach segment, maintain vertical (as applicable) and lateral guidance within ¾-scale deflection.
9. Avoid loss of aircraft control, or attempted flight contrary to the engine-inoperative operating limitations of the aircraft.
10. Comply with the published criteria for the aircraft approach category when circling.
11. Execute a normal landing.
12. Complete the appropriate checklist.

NIGHT OPERATIONS

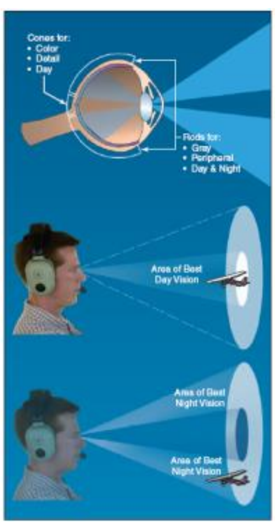
XI.A. Night Preparation

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25), AIM, POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Physiological Aspects of Night Flying as it Relates to Vision**
   - A. How the Eyes Works
     - i. Rods and Cones
       - a. Two types of light sensitive nerve endings which transmit messages to the brain via the optic nerve
         - Cones - Responsible for color, detail, and far away objects
           - a The cones are located 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 located in a ring around the cones (peripherals)
       - 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
       - c. Rods, Cones, and Night Vision
         - Cones are located in the center of the retina (the layer upon which all images are focused)
           - a There is a small pit called the fovea where almost all the light sensing cells are cones
             - 1. This is the area where most looking occurs (your center of vision)
         - The Rods
           - a Make night vision possible
           - b During daylight, objects can be seen by looking directly at them, using the fovea, but at night a scanning procedure to permit off center viewing is more effective
             - a. The cones need light to function, without sufficient light (at night, for example) the cones are effectively a blind spot
           - c Rods are concentrated around the cones and are used to see in dim light
             - 1. 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
             - 2. 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
           - d 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)
             - 1. The rods can take approximately 30 minutes to fully adapt to the dark
               - a. Once fully adapted the Rods are about 100,000x more sensitive to light
             - 2. After the rods have adapted to the dark, the process is reversed when exposed to light
               - a. They eyes adjust to the light in a matter of seconds
               - b. If a dark room is reentered, the 30-min process to adapt is started again
                 - **i.** Therefore, it is important to avoid bright lights before and during a flight
                 - **ii.** This is why red flashlights are recommended during flight, they do not disrupt the rods dark adaptation



       - d. Summary

- Night vision is based on the rods and off-center viewing is necessary
- 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
- It is important to avoid bright lights before and during a flight to maintain adequate night vision

ii. Cockpit Lighting
   a. Cockpit lighting should be at a minimum brightness that will allow reading of the instruments and switches without hindering outside vision

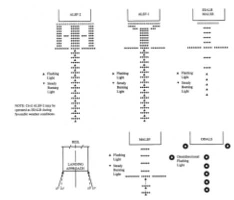
B. Night Illusions
   i. In addition to night vision limitations, be aware that night illusions can cause confusion
   ii. Autokinesis
      a. Caused by staring at a single point of light against a dark background for over a few seconds
      b. The light appears to move on its own
      c. Prevent this by focusing the eyes on objects at varying distances and avoid fixating
         - Keep the eyes moving and offset/use peripherals
   iii. False Horizon
      a. Caused when the natural horizon is obscured/not readily apparent
         - Generated by confusing bright stars and city lights
      b. Use and trust your instruments to maintain orientation
   iv. Featureless Terrain
      a. An absence of ground features can create the illusion that the aircraft is higher than it actually is
      b. This results in a tendency to fly a lower-than-normal approach
   v. Runway Slopes
      a. An up-sloping runway/terrain can create the illusion that the aircraft is higher than it actually is
         - The pilot who does not recognize this will fly a lower approach
      b. Downslope – The opposite applies
      c. To mitigate this illusion, be prepared, use the Chart Supplement to know what runway slope to expect
   vi. Ground Lighting
      a. Regularly spaced lights along a road/highway/etc. can appear to be runway lights
      b. Lights on moving trains have been mistaken for runway/approach lights
      c. Bright runway or approach lights can create the illusion the airplane is closer to the runway
      d. Mitigate this as much as possible by maintaining situational awareness
         - 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.)
   vii. Verify Attitude by Reference to the Flight Instruments
      a. Reference to the flight instruments is the best way to cope with disorientation/optical illusions
         - If making an approach and an ILS or VASI is available, make use of it
            a Use vertical guidance as much as possible, especially at night
      b. Visual references are limited – incorporate the instruments in your scan more often than normal
      c. If at any time the pilot is unsure of their position, a go around should be executed

2. Lighting Systems Identifying Airports, Runways, Taxiways, and Obstructions, as well as Pilot Controlled Lighting

A. The lighting systems used for airports, runways, obstructions, and other visual aids at night are other important aspects of night flying
   i. It is important not to only know the exact location of an airport relative to a city at night, but also to be able to identify these airports by characteristics of their lighting pattern

ii. The following is a very in-depth look at just about every type of light that can exist on an airfield. This is obviously overkill for a private pilot student, but if you or the student have any questions on lights, the answer should be in here:

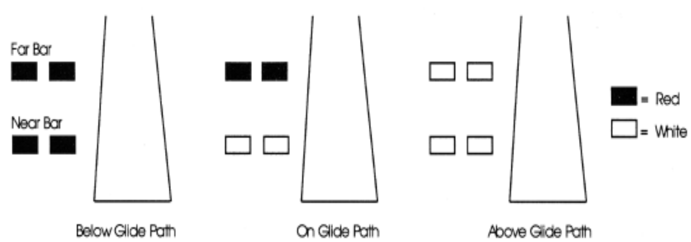
B. Approach Light Systems (ALS)



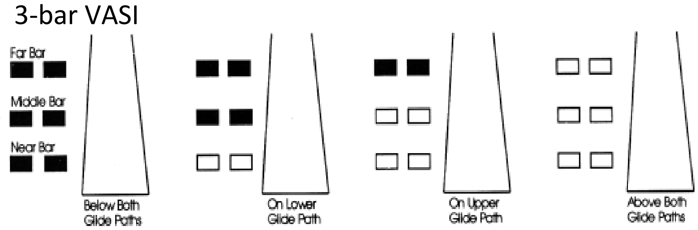
- i. Purpose - The basic means to transition from instrument conditions to visual conditions for landing
- ii. Explanation - A configuration of signal lights starting at the landing threshold and extending into the approach area

C. Visual Glideslope Indicators

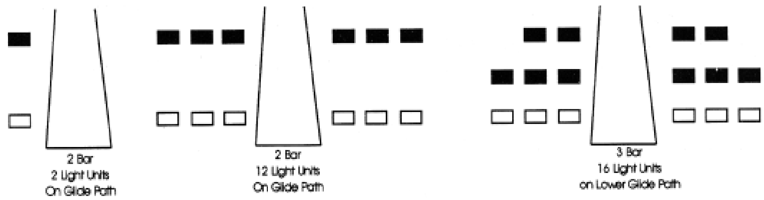
- i. Visual Approach Slope Indicator (VASI)
  - a. Purpose - Provide visual descent guidance information during approach
  - b. Explanation - The lights are visible from 3-5 miles during day and up to 20 or more at night
    - Safe obstruction clearance within ± 10° of the centerline and 4 NM from the threshold
  - c. Configurations
    - 2, 4, 6, 12, or 16 light units arranged in bars
      - a Arranged as near, middle, and far bars (Mid provide another glide path for high cockpits)
      - b VASIs of 2, 4, or 6 light units are located on one side of the runway (usually the left)
      - c VASIs consisting of 12 or 16 light units are located on both sides of the runway
    - Most installations consist of 2 bars and may consist of 2, 4, or 12 light units
  - d. Two Bar VASIs
    - Provide one visual glide path, normally set at 3°
  - e. Three Bar VASIs
    - Provide two visual glide paths
      - a The lower glide path is provided by the near and middle bars and is normally set to 3°
        1. Some locations may have up to 4.5° glide paths for proper obstacle clearance
      - b The upper glide path is provided by the middle and far bars and is normally set ¼° higher
  - f. 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. For other VASI configurations



D. Precision Approach Path Indicator (PAPI)
   i. General
      a. Lights arranged to provide visual descent guidance information during the approach to a runway
      b. Uses light units similar to the VASI but in a single row of either 2 or 4 light units
   ii. Configuration
      a. Tri-Color Systems
         - Normally a single unit projecting a 3-color visual approach path into the final approach area
         - Glide Path Indications
            a Below - Red
            b Above - Amber
            c On - Green
         - Useful Range
            a Day - ½ to 1 mile
            b Night - Up to 5 miles (depending on the visibility)
      b. Pulsating Systems
         - Normally a single unit projecting a 2-color visual approach path into the final approach area
         - Glide Path Indications
            a Slightly Below - Steady red
            b Below - Pulsating red
            c On - Steady white
            d Slightly Above - Pulsating white
            e Above - Faster pulsating white
               1. Pulsating increases as the aircraft gets further above/below the glide slope
         - Useful Range
            a Day, up to 4 miles
            b Night, up to 10 miles

E. Runway End Identifier Lights (REIL)
   i. General - Installed to provide rapid/positive identification of the approach end of a runway
   ii. Configuration - A pair of synchronized flashing lights located on each side of the runway threshold
   iii. Effective for:
      a. Identification of a runway surrounded by a preponderance of other lighting
      b. Identification of a runway which lacks contrast with the surrounding terrain
      c. Identification of a runway during reduced visibility

F. Runway Edge Light Systems (HIRL, MIRL, LIRL)
   i. General - Outline the edges of runways during periods of darkness or restricted visibility conditions
      a. Classified according to the intensity or brightness they are capable of producing
         - High Intensity (HIRL); Medium Intensity (MIRL); Low Intensity (LIRL)
            a HIRL and MIRL have variable intensity controls
   ii. Configuration
      a. Runway edge lights - White
         - Instrument runways - Turn yellow the last 2,000,’ or half the runway, whichever is shorter
      b. Lights marking the end of the runway - Red/Green

            - Red is emitted toward the runway to indicate the end of the runway to a departing aircraft
            - Green is emitted outward from the runway end to indicate the threshold to landing aircraft

G. In-runway Lighting
    i. 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
    ii. Touchdown Zone Lights (TDZL)
        a. General - On some precision runways, indicating the touchdown zone with adverse visibility conditions
        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
    iii. 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
    iv. 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)
    v. 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

H. Control of Lighting Systems
    i. Operation of approach light systems and runway lighting is controlled by the control tower/FSS
    ii. Pilots may request the lights be turned on or off

I. Pilot Control of Airport Lighting
    i. Radio control of lighting is available at some airports by keying the aircraft’s microphone
        a. Often available at airports without specified hours for lighting, airports with no tower/FSS, or when the airport is closed
    ii. All lighting systems which are radio controlled at an airport operate on the same frequency
        a. The CTAF is used to activate the lights at most airports, but other frequencies may also be used
            - The frequency is in the Chart Supplement and the standard instrument approach procedures publications
            - It is not identified on the sectional charts

Runways with Approach Lights

Lighting System	No. of Intensity Steps	Status During Nonuse Period	Intensity Step Selected Per No. of Mike Clicks		
			3 Clicks	5 Clicks	7 Clicks
Approach Lights (Med. Int.)	2	Off	Low	Low	High
Approach Lights (Med. Int.)	3	Off	Low	Med	High
MIRL	3	Off or Low	◆	◆	◆
HIRL	5	Off or Low	◆	◆	◆
VASI	2	Off	✯	✯	✯

NOTES: ◆ *Predetermined intensity step.*
✯ *Low intensity for night use. High intensity for day use as determined by photocell control.*

Runways without Approach Lights

Lighting System	No. of Intensity Steps	Status During Nonuse Period	Intensity Step Selected Per No. of Mike Clicks		
			3 Clicks	5 Clicks	7 Clicks
MIRL	3	Off or Low	Low	Med.	High
HIRL	5	Off or Low	Step 1 or 2	Step 3	Step 5
LIRL	1	Off	On	On	On
VASI ✯	2	Off	◆	◆	◆
REIL ✯	1	Off	Off	On/Off	On
REIL ✯	3	Off	Low	Med.	High

NOTES: ◆ #32; Low intensity for night use. High intensity for day use as determined by photocell control.
✯ #32; The control of VASI and/or REIL may be independent of other lighting systems.

Radio Control System

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)

J. Airport Beacons
   i. Vertical light distribution to make them more effective from 1° to 10° above the horizon
      a. They can be seen well above and below this spread
   ii. Light Projection
      a. Omnidirectional capacitor discharge device
      b. Rotate at a constant speed
   iii. Flashes

            a. 24-30 per minute for airports/landmarks/points on federal airways; 30-45 per minute for heliports
        iv. Colors and Combinations of Beacons
            a. White and Green - Lighted land airport
            b. *Green alone - Lighted land airport
            c. White and Yellow - Lighted water airport
            d. *Yellow alone - Lighted water airport
            e. Green, Yellow, and White - Lighted heliport
        v. Military Beacons
            a. Two quick white flashes followed by a green flash
        vi. Operation during the day
            a. In Class B, C, D and E surface areas, operation of the airport beacon during the hours of daylight often indicates that the ground visibility is less than 3 miles and/or the ceiling is less than 1,000'
                - Don't rely solely on the airport beacon to indicate if weather conditions are IFR or VFR
                    a There is no regulatory requirement for daylight beacon operation
    K. 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
    L. Obstruction Lighting
        i. Obstructions (towers, buildings, etc.) are marked with flashing or steady red or white lights
            a. Sometimes the same structure will be lit by white lights during the day and red at night

3. Airplane Equipment and Lighting Requirements for Night Operations

    A. FAR 91.205: Required equipment for VFR flight at night:
        i. TOMATO FFLAMES (day required equipment) and FLAPS (night required equipment)
            a. Fuses (if applicable)
            b. Landing Light
            c. Anti-Collision Lights
            d. Position Lights

        e. Source of Power
    ii. Instrument required equipment doesn't hurt (safer is smarter)
  B. Airplane Lighting Systems Information (not necessarily requirements)
    i. Type
        a. Taxi/Landing Lights
        b. Strobe Lights (Anti Collision Lights)
        c. Nav Lights (Position Lights)
            - A red light is on the left wingtip
            - A green light is on the right wingtip
            - A white light is on the tail
    ii. Interpretation in Flight
        a. Position (Nav Lights)
            - If both a red and green light are observed, the aircraft would be flying toward the pilot
            - If only a red light is visible, you are viewing the left side of the aircraft and opposite for a green light
    iii. When to use each Lighting System
        a. Taxi/Landing
            - While taxiing, do not point your taxi/landing lights directly at/across the landing path or another aircraft
                - a It can be very distracting, blinding, and disorienting to the pilot
            - Landing lights are not only useful for taxi, takeoff, and landing, but also provide a means to be more visible at night
                - a Pilots are encouraged to turn on the landing/taxi lights when within 10 miles of an airport (day or night)
        b. Strobe Lights (Anti Collision Lights)
            - Do not use strobes in vicinity of other aircraft at night on the ground
                - a These can be distracting, and blinding to other pilots
            - Otherwise, the strobe lights are often used at all times
                - a And can be used to signify engine start
        c. Nav Lights (position lights)
            - Nav lights are primarily used for night operations, but again can be used at all times to allow visibility
            - Position lights are often also used to warn people in the vicinity that the aircraft power is on and the engine may be starting shortly

4. Personal Equipment Essential for Night Flight

  A. Flashlight
    i. Red/Green or white light
        a. White light is used to preflight the aircraft
        b. Red and/or Green light is used when performing cockpit operations as it will not impair night vision
            - Be cautious, when using a red/green light on an aeronautical chart, the red/green colors will wash out
  B. Aeronautical Charts
    i. If the intended course of flight is near the edge of a chart, the adjacent chart should be available
        a. City lights can be seen at far distances and confusion can result without the necessary charts
  C. Regardless of equipment, organization eases the burden on the pilot

5. Night Orientation, Navigation, and Chart Reading Techniques

A. Checkpoints – Although there are less of them, it does not pose a problem
   i. Light patterns of towns are easily identified
   ii. Rotating beacons are useful
   iii. Highways with cars on them are usually easy to see (headlights/brake lights are visible)
   iv. Ensure you maintain orientation as it is easier to become disoriented and confused about location
      a. Continuously monitor position, time estimates, and fuel consumed
   v. NAVAIDS/GPS should be used whenever possible
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 the ground and glowing around lights
      b. Be conservative, don't expect to pop out the other side, take action as necessary to avoid flying in the clouds
C. Chart Reading
   i. Use a green or red light to conserve night vision
      a. Be cautious as the green or red colors on the chart will wash out in the light
   ii. Fly first, remember to return to the aircraft frequently to ensure proper navigation/attitude

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. Collision Hazards to Include Aircraft, Terrain, Obstacles and Wires
A. Collision Avoidance
   i. Operation Lights On
      a. A voluntary FAA safety program to enhance the see and avoid concept
      b. Pilots are encouraged to turn on their landing lights during takeoff and whenever operating below 10,000', day or night, especially when operating within 10 miles of any airport, or in conditions of reduced visibility, and in areas where flocks of birds may be expected (coastal areas, lake area, refuse dumps, etc.)
   ii. 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 at approximately the same altitude (except head on), the aircraft to the other's right has the right-of-way.
         - If they are different categories:
            a A balloon has the right of way over any other category
            b A glider has the right of way over an airship, powered parachute, weight-shift controlled aircraft, airplane, or rotorcraft
            c An airship has the right-of-way over a powered parachute, weight shift controlled aircraft, airplane, or rotorcraft
            d However, an aircraft towing or refueling other aircraft has the right-of-way over all other engine driven aircraft
      c. Approaching Head-on
         - Each pilot shall alter course to the right
      d. Overtaking
         - The aircraft being overtaken has the right-of-way and each pilot of an overtaking aircraft shall alter course to the right to pass well clear

e. Landing
   - Aircraft on final approach to land or landing have the right-of-way over aircraft in flight or operating on the surface
     - a Do not take advantage of this rule to force an aircraft off the runway surface which has already landed and is attempting to make way for an aircraft on approach
   - When two or more aircraft are approaching for landing, the aircraft at the lower altitude has the right-of-way
     - a Don't take advantage of this rule to cut in front of another aircraft

iii. Minimum Safe Altitudes (FAR 91.119)
   a. Except when necessary for takeoff and landing, no aircraft may operate below the following altitudes:
      - 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' of the aircraft when over any congested area of a city, town, or settlement, or over any open-air assembly of persons
      - Over other than Congested Areas: 500' above the surface, except for over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500' to any person, vessel, vehicle, or structure

iv. Clearing Procedures
   a. In the Descent: Execute gentle banks to allow visual scanning of other traffic above/below the wings as well as other blind spots
   b. Straight-and-Level Flight: Execute clearing procedures at appropriate intervals
      - This is also more applicable to cruise, but can be used while the pattern, if necessary
   c. Traffic Patterns: Enter at pattern altitude. Do not enter while descending to prevent descending onto another aircraft

v. Visual Scanning Techniques during Night Operations
   a. Effective Scan
      - Look from left to right or from right to left
      - Start at the greatest distance an object can be perceived and move inward toward the position of the aircraft
      - For each stop, an area approximately 30 degrees wide should be scanned
        - a The duration of each stop is based on the degree of detail required, but no longer than 2-3 seconds
      - When moving from one viewing point to the next, overlap the previous field of view by 10 degrees
   b. Off Center Viewing
      - View an object by looking 10 degrees above, below, or to either side of the object
        - a This allows the peripheral vision to maintain contact with the object
      - Objects viewed more than 2-3 seconds will disappear because of the way rods work
      - Shift off the object and back to it to maintain view

B. Terrain
   i. Be aware of terrain in the vicinity of the airfield, and any terrain that could cause a hazard during the climb or descent into the airfield
      a. Study sectionals and terminal area charts
      b. To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.

c. Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

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

- Know safe altitudes to fly and verify your position to ensure you remain clear of hazardous terrain

b. A personal minimum may be to only fly over high terrain during daylight

C. Obstacle and Wire Strike Avoidance

i. Many structures exist that could significantly affect the safety of flight when operating below 500' AGL and particularly below 200' AGL

a. This becomes a large factor at the low altitudes associated with the traffic pattern and approach to landing

b. Become familiar with any obstacles on the approach and departure path

c. Obstacles can be found in the NOTAMs, as well as in the Terminal Procedures (IFR Document)

d. At and below 200' AGL there are numerous power lines, antenna tower, etc. that are not marked and lighted as obstructions and therefore may not be seen

e. NOTAMs are issued on lighted structures experiencing light outages

ii. Antenna Towers

a. Extreme caution should be exercised below 2,000' AGL due to numerous antennas that extend over 1,000'-2,000' AGL. Most structures are supported by guy wires which are very difficult to see

- Avoid all structures by at least 2,000' as these wires can extend 1,500' horizontally from a structure

iii. Overhead Wires

a. Often overhead transmission wires and lines span departures from runways and other landmarks pilots frequently follow or fly over (lakes, highways, railroad tracks, etc.)

b. These wires and lines may or may not be lighted

c. Be extremely vigilant on takeoff and landing

2. Distractions, Loss of Situational Awareness, and/or Improper Task Management

A. Distractions

i. The pilot's attention should be focused on the tasks at hand, especially at night when visual references are reduced

a. Flying takes precedence

- Aviate, Navigate, Communicate

ii. If something is too distracting remove it from your field of view or, in the case of a person, explain the situation and ask them to stop whatever they are doing.

a. Remove the distraction prior to it becoming enough of a hazard

iii. Distractions can lead to various dangerous situations (slow airspeeds, collisions, disorientation, unusual attitudes, missed radio calls, unsafe descents or climbs, etc.)

a. Manage tasks appropriately to stay ahead of the aircraft and ensure all necessary checklists have been completed, and both you and the aircraft are prepared for the approach and landing

B. Loss of Situational Awareness

i. Getting Lost

a. Ground references are sparser at night

- This can make navigation both easier and harder

a It can be easier since individual points are easier to find and aren't hidden in the clutter visible during the day

- b At the same time, since there are fewer points and some of them can look very similar it can be easy to mistake reference points for something they're not
- For these reasons, the pilot must divide attention between flying and navigating
  - a Always be aware of your position
  - b Back it up with multiple references, if possible (for example, a city and a road)
    1. Use a road as a funnel to a waypoint
  - c Back it up with GPS and other navaids (use VORs to find a radial/dme or to triangulate your position)

ii. Getting Disoriented
- a. Divide your attention between flying, navigating, communicating, and looking at the map
  - Long periods of time spent with your head down looking at a map can result in disorientation when you look back up, or a lack of control of the aircraft also leading to disorientation
- b. Include the instruments in your cross check more often at night than you would during the day

C. Task Management

i. In spite of fewer reference points, night flying does not present particular problems if preplanning is adequate, and the pilot continues to monitor position, time estimates, and fuel used
- a. Navaids should be used to assist in monitoring progress (as well as GPS, if available)
- b. Stay ahead of the aircraft, and divide attention between the tasks at hand

ii. A failure to manage tasks could result in many situations, such as:
- a. Getting lost
  - Low fuel state
- b. Disorientation
- c. Inadvertent IMC
- d. Unusual Attitude, or a loss of control

iii. Divide Attention and continue to monitor your position!

3. Hazards Specific to Night Flying

A. Safety Precautions

i. Engine Start
- a. Be very sure the propeller area is clear
  - Turn on position and anti-collision lights prior to start
  - Announce "Clear Prop"

ii. Taxiing, Airport Orientation, and the Run-up
- a. Taxiing
  - Due to restricted vision, taxi speeds should be reduced
    - a Don't taxi faster than a speed that will allow a stop within the distance you can clearly see
  - Use the landing/taxi lights as necessary
  - Do not use strobes or landing lights in vicinity of other aircraft
    - a These can be distracting, and blinding to other pilots
- b. Orientation
  - Airport Diagram (always have one out)
  - Understanding taxiway markings, lights, and signs
- c. The Run-up
  - The before taxi run-up should be performed with the checklist as usual
  - Forward movement of the airplane may not be easy to detect

- Hold/lock the brakes and be alert that the airplane could creep forward without being noticed
- Be extra cautious

B. Emergencies
   i. Electrical
      a. The greatest electrical load is placed on the system at night = the greatest chance of failure
      b. In the case of a suspected problem
         - Reduce load as much as feasible
         - If total failure is expected, land at the nearest airport immediately
   ii. Engine
      a. Don't Panic - Establish a normal glide and turn toward an airport or away from congested areas
      b. Check to determine the cause and correct immediately if possible (Engine restart checklist)
      c. 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
      d. Announce the emergency to ATC, UNICOM, and/or guard (If on a frequency, don't change unless instructed to)
      e. Consider an emergency landing area close to public access (don't land where no one can get to you)
         - Before landing checklist
         - Touchdown at the slowest possible airspeed
      f. After landing, turn off all switches and evacuate as quickly as possible

C. Somatogravic Illusion and Black Hole Approach Illusion
   i. Somatogravic Illusion
      a. A rapid acceleration, such as experienced during takeoff, can create the illusion of being in a nose up attitude. The pilot may push the aircraft into a dive attitude
      b. A rapid deceleration can have the opposite effect
      c. Trust the instruments, not the feelings
   ii. Black Hole Approach Illusion
      a. An absence of surrounding ground features, as in an overwater approach over darkened areas or terrain made featureless by snow, can create an illusion that the aircraft is at a higher altitude than it actually is
      b. This illusion causes pilots to fly a lower approach than is desire
      c. Use any references available. Things such as VASIs and PAPIs or the ILS glideslope can provide approach information

D. Disorientation at Night
   i. False Horizon or a lack of a Horizon
      a. Due to an obscured natural horizon, a merging or city and star lights, etc. a false horizon can be trusted at night
         - Trust your instruments, include them in your crosscheck
      b. Lack of Horizon
         - When flying over empty terrain, or water the natural night horizon can blend seamlessly with the water/terrain making flight by visual references difficult and recovery from an unusual attitude with visual references very difficult
      c. Trust the instruments and include them in your crosscheck
   ii. Without visual references the pilot is also susceptible to spatial disorientation just as though he or she was in IMC

        a. The Leans
        b. Coriolis Illusion
        c. Graveyard Spiral
        d. Somatogravic Illusion
        e. Inversion Illusion
        f. Elevator Illusion
    iii. Ignore the incorrect feelings, and trust the instruments

E. Inadvertent IMC
    i. It is difficult to see clouds at night – be cautious to avoid flying into MVFR/IFR weather conditions
        a. Clouds can come out of nowhere
        b. Normally though, the 1st indication is a gradual disappearance of the ground and glowing around lights
        c. Be conservative, don't expect to pop out the other side, take action as necessary to avoid flying in the clouds
            - Ask for assistance, weather reports; divert if necessary; use the autopilot and transition to the instruments
            - Turn around if necessary to get out of the weather
    ii. Disorientation
        a. It can be as disorienting, if not more disorienting than inadvertent IMC during the day
            - Trust and use the instruments - don't try to attempt to fly visually
    iii. Lighting
        a. The strobes, landing/taxi lights can be overwhelming in clouds at night
            - The strobes flashing can overwhelm the cockpit with light, turn them off if necessary
            - Landing/taxi lights can be distracting and overwhelming
                a They can provide an overwhelming sensation of movement through the clouds
                b Turn them off it they're distracting
    iv. Other Traffic
        a. Once in IMC it is almost impossible to see another aircraft that may be on a collision course
            - Be very cautious, use ATC flight following, and any other tools available (TCAS)

F. Environmental Considerations at Night
    i. IMC
        a. If inadvertent IMC is encountered, transition to the instruments (use the autopilot, if available) and head toward the closest know VMC (maybe behind you)
        b. Ask for help
            - ATC can provide vectors, and reports from other aircraft nearby
    ii. Terrain
        a. Plan ahead, know what altitude is necessary to clear any terrain in your vicinity and fly at that altitude
    iii. False/No Horizon
        a. Continue scanning outside for other traffic, but use the instruments for navigation
            - Use the autopilot, if available
    iv. Water
        a. Crossing large bodies of water at night in single engine airplanes could be potentially hazardous, not only from the standpoint of landing (ditching) in the water, but also because with little or no lighting the horizon blends in with the water
            - This can result in a loss of orientation

SKILLS

The applicant demonstrates the ability to:

Note: Not generally evaluated in flight. If the practical test is conducted at night, all ACS Tasks are evaluated in that environment, thus there is no need for explicit Task elements to exist here.

POSTFLIGHT PROCEDURES

XII.A. After Landing, Parking and Securing

References: Airplane Flying Handbook (FAA-H-8083-3), Risk Management Handbook (FAA-H-8083-2), POH/AFM

KNOWLEDGE

The applicant demonstrates understanding of:

1. **Aircraft Shutdown, Securing, and Postflight Inspection**
   A. Engine Shutdown
      i. Always use the procedures in the manufacturer's checklist for shutting down the engine and securing the aircraft
      ii. Some of the important items include:
         a. Set the parking brakes
         b. Set the throttle to idle or 1000 rpm
            - If turbocharged, observe the spool down procedure
         c. Turn the ignition switch off then on at idle to check for proper operation of switch in the off position
         d. Set the propeller control (if equipped) to full increase
         e. Turn electrical units and radios off
         f. Set mixture control to idle cutoff
         g. Turn the ignition switch to off when the engine stops
         h. Turn the master electrical switch to off
         i. Install the control lock
   B. Securing
      i. When the flying is complete for the day, the aircraft should be hangared or tied down and the flight controls secured
   C. Postflight Inspection
      i. After engine shutdown and passenger deplaning, the pilot should perform a postflight inspection
         a. This includes checking the general condition of the aircraft
         b. If departing again, the oil should be checked and fuel added, if required
         c. If the aircraft is going to be inactive, it is a good operating practice to fill the tanks to the top to prevent water condensation from forming
2. **Documenting In-Flight/Postflight Discrepancies**
   A. Get the Issues fixed
      i. Don't leave problems for the next pilot
         a. Safety is #1, if you don't report an issue, the next person may not be aware of the issue and has to deal with it
            - Treat it as though it's your aircraft
            - Don't put another pilot in a dangerous situation
            - The longer it takes for the problem to get reported, the longer it takes for someone to start working on the problem to get the aircraft back in service
               a If you see or experience an issue, report it as soon as you can
   B. Documenting Issues allows others to see a history of problems the aircraft has experienced
      i. Pilots can note trends before taking the aircraft
         a. For example, If the aircraft tends to have a problem with a specific piece of equipment needed for a trip, the pilot can take a different aircraft or get the issue fixed

RISK MANAGEMENT

The applicant demonstrates the ability to identify, assess, and mitigate risks, encompassing:

1. **Inappropriate Activities and Distractions**
   A. Distractions lead to ground incursions
      i. Distractions can include updating the GPS, changing navaids, phone calls/texts (just because you have cell phone service doesn't mean you should pull out your phone), etc.
      ii. Avoid these entirely while taxiing; wait until the aircraft is safely stopped with the parking brake set before you go 'heads down'
   B. Any activities other than those associated with taxiing, parking, and shutting down the aircraft are inappropriate and should be reserved until after all checklists are complete
2. **Confirmation or Expectation Bias as Related to Taxi Instructions**
   A. Often times pilots get complacent with taxi instructions – you hear and repeat and taxi the same route consistently
      i. This can turn into confirmation or expectation bias – the pilot hears what he or she expects to hear, even though the instructions may have changed
   B. Listen
      i. Always listen to the instruction, and repeat what you hear - even if you expect to hear the same thing you always have
         a. Clarify the instructions with ATC if you're ever unsure
      ii. Sooner or later the instructions will change (construction, hazard, another aircraft, etc.). Recognize the change and avoid an incursion
3. **Airport Specific Security Procedures**
   A. This is more of an issue now than it has ever been
      i. If you see someone who doesn't look like they should be there, tell someone, do something
      ii. Wait for gates to close behind you, don't let anyone who isn't authorized into the airport area
   B. Certain airports have specific procedures, follow those procedures for everyone's safety
      i. Don't disclose gate codes, security information, etc. with those who are not authorized or required to know
4. **Disembarking Passengers**
   A. Ensure the passengers safety is of the highest importance when disembarking
      i. The aircraft should be shutdown, or configured in a manner which allows for safe movement as required, and chocked to prevent movement
   B. Do not let the passengers disembark until all required checklists are completed and safety precautions are met

SKILLS

The applicant demonstrates the ability to:

1. Demonstrate runway incursion avoidance procedures.
2. Park in an appropriate area, considering the safety of nearby persons and property.
3. Complete the appropriate checklist.
4. Conduct a postflight inspection and document discrepancies and servicing requirements, if any.
5. Secure the aircraft.