2025-05-14 - POF Lecture 3

> Date & Time: 2025-05-14 15:33:45
> Location: [Insert Location]
> [Insert Title]
> `Aircraft Stall and Recovery` `Aerodynamic Control Surfaces` `Propeller Theory`

Theme

This lecture provides an in-depth overview of aircraft aerodynamics, focusing on stall phenomena, control surfaces, trim systems, and propeller theory. Key topics include stall characteristics, recovery procedures, effects of load factor, flap types, boundary layer behavior, and battery systems in aviation. Practical examples, real-world accident scenarios, and exam preparation tips are included to enhance understanding and safety awareness for aviation students.

Takeaways

1. Purpose and function of aircraft trim
2. Control force ratios for aileron, elevator, and rudder
3. Effect of load factor on control force
4. Construction and function of control columns
5. Balance tabs and anti-balance tabs: definitions and functions
6. Servo tabs and their use in large aircraft
7. Flutter: causes, effects, and prevention
8. Mass balance and its role in preventing flutter
9. Stabilator and its characteristics
10. Trimming controls: operation and purpose

Highlights

- `"It doesn't matter if the aircraft is perfectly designed that we always keep the CG within the limits and absolutely everything. We always have to use the trim, okay? No matter what."`
- `"If the tail goes down, the nose goes up."`

- `"The natural movement of the air wants to escape from high region pressure to the low region pressure."`
- `"You will learn to fly from the real flying experience, not from the books."`
- `"The fact that the aircraft pitches nose down at the stone does not amount to a sub-recovery. The angle of attack of the wings still has to be reduced by moving the control cone forward."`
- `"This is why it's important to be 100% concentrated on your flight."`
- `"Whenever you have to carry out a check, whenever you have to check if the voltmeter is working properly, then you need to supply it with current, and otherwise it would be on zero."`
- `"Imagine you put honey in instead of water. It's not going to flow steady, okay?"`

Chapters & Topics

Aircraft Trim: Purpose and Function

> Trim in aircraft is used to reduce control forces required by the pilot, thereby decreasing workload and improving flight comfort and safety. Most aircraft, especially in air and aviation, are equipped with trim systems. The main idea is to allow the pilot to maintain a desired flight attitude without continuous force on the control column.

- **Keypoints**
  - Trim reduces the workload on the pilot by minimizing the need to apply continuous force to the controls.
  - Trim is especially useful during phases like climb, cruise, and level flight.
  - Manufacturers design trim systems so that control forces are balanced and coordinated.
- **Explanation**
  Without trim, pilots would have to constantly apply force to maintain flight attitude, especially during VFR when multitasking is required. Trim allows hands-off flying for short periods, but pilots must remain attentive to flight parameters.
- **Examples**
  > As soon as you lift off and begin climbing, you start trimming the aircraft to maintain the desired attitude with a specified power setting.

  - After takeoff, set the desired climb attitude and power.
  - Adjust the trim so that the aircraft maintains this attitude without continuous input.

    - This reduces pilot workload and allows focus on navigation and other tasks.
- **Considerations**
- Always use trim regardless of aircraft design or CG position.
- Do not use trim as an excuse to become distracted from flight parameters.
- **Special Circumstances**
- If the trim is not reducing control force as expected, check if the trim is connected or functioning properly.

Control Force Ratios and Load Factor Effects

> Manufacturers specify the ratio of forces required on the aileron, elevator, and rudder after trimming: aileron (1), elevator (2), rudder (4). Load factor increases the required control force on the control column.

- **Keypoints**
    - Aileron should be the lightest (1), elevator moderate (2), rudder hardest (4) after trimming.
    - As load factor increases, the required pull force on the control column increases.
    - For a load factor of 2g, the required force is 20 pounds.
- **Explanation**
  These ratios ensure the pilot has the correct tactile feedback and prevents over-controlling. Increased load factor (e.g., during maneuvers) increases the force needed to move the controls.
- **Examples**
  > During a maneuver with a load factor of 2g, the pilot feels 20 pounds of force on the control column.

    - The load factor doubles from 1g to 2g.
    - The control force required increases proportionally, so the pilot must exert more effort.
- **Considerations**
- Understand the force ratios to avoid over-controlling.
- Be aware of increased control forces during high-load maneuvers.
- **Special Circumstances**
- If the control force feels abnormal, check for trim or mechanical issues.

Balance Tabs, Anti-Balance Tabs, and Servo Tabs

> Tabs are small surfaces on control surfaces that help adjust the force required to move the main control surface. Balance tabs move in the opposite direction to the

> control surface to reduce force, anti-balance tabs move in the same direction to increase force, and servo tabs use hydraulic actuators in large aircraft.

- **Keypoints**
  - Balance tab: moves opposite to elevator, reduces control force.
  - Anti-balance tab: moves in same direction as elevator, increases control force.
  - Servo tab: found on large aircraft, uses hydraulics instead of springs.
- **Explanation**
  Tabs are designed to assist or resist pilot input as needed for safety and handling. Balance tabs make controls lighter, anti-balance tabs make them heavier to prevent over-controlling, and servo tabs provide hydraulic assistance.
- **Examples**
  > When the elevator is moved down, the balance tab moves up, reducing the force required by the pilot.

  - Pilot moves elevator down.
  - Balance tab moves up, aerodynamic force assists movement.
  - Pilot feels less resistance.
- **Considerations**
- Know which type of tab is installed on your aircraft.
- Understand the direction of movement for each tab type.
- **Special Circumstances**
- If the elevator is too light or too heavy, check the tab configuration and function.

Flutter and Mass Balance

> Flutter is a rapid oscillation or vibration of the control surface, potentially leading to structural failure. Mass balance is used to prevent flutter by moving the center of gravity of the control surface forward, preferably to the hinge line.

- **Keypoints**
  - Flutter can occur if the aircraft exceeds the never exceed speed (Vne).
  - Mass balance involves adding weight to the forward part of the control surface.
  - Proper mass balance reduces the risk of flutter.
- **Explanation**
  Flutter is dangerous and can destroy the airframe. Mass balancing the control surfaces ensures stability and prevents oscillations.
- **Examples**
  > If the aircraft exceeds the never exceed speed, flutter may occur, causing rapid vibration and possible structural failure.

  - Aircraft accelerates beyond Vne.

    - Airframe is not designed for such speeds.
    - Uncontrolled oscillation (flutter) develops.
    - Mass balance helps prevent this by stabilizing the control surface.
- **Considerations**
- Always respect the never exceed speed.
- Check for mass balance weights during preflight inspections.
- **Special Circumstances**
- If vibration is felt in the control column, reduce speed immediately and check for possible flutter.

Stabilator and Anti-Balance Tab

> A stabilator is a large surface that acts as both a horizontal stabilizer and elevator. Anti-balance tabs are always present on stabilators to prevent over-controlling and to provide appropriate control force feedback.

- **Keypoints**
    - Stabilator combines stabilizer and elevator functions.
    - Anti-balance tab increases control force as the control column is moved.
    - Reduces sensitivity and prevents over-controlling.
- **Explanation**
  The anti-balance tab moves further into the airflow as the control column is moved, increasing the force required and reducing sensitivity.
- **Examples**
  > The Piper and Techno 2008, 2002, and multi-engine Techno aircraft have stabilators with anti-balance tabs to ensure proper control feel.

    - Pilot moves control column.
    - Anti-balance tab increases resistance.
    - Prevents over-controlling and maintains safe handling.
- **Considerations**
- Be aware of increased control force with stabilators.
- Understand the design differences between aircraft.
- **Special Circumstances**
- If the control column feels too light or sensitive, check the anti-balance tab function.

Trim Controls: Operation and Procedures

> Trim controls can be mechanical (wheel) or electrical (button). The main purpose is to reduce control force on the stick. Proper procedure involves achieving the

> desired airspeed before trimming, and adjusting the trim until no push or pull is needed to maintain attitude.

- **Keypoints**
  - Mechanical trim: wheel moved up/down; electrical trim: button pressed.
  - Trim only after reaching desired airspeed and power setting.
  - Trim wheel forward for constant push force (nose down), backward for pull force (nose up).
  - Trim indication shows neutral, nose up, or nose down positions.
- **Explanation**
  Trimming before reaching the correct airspeed or power setting can result in improper aircraft attitude. Always trim after stabilizing flight parameters.
- **Examples**
  > After leveling off and accelerating to cruise speed, reduce power and then trim the aircraft for hands-off flight.

  - Level off at cruise altitude.
  - Accelerate to cruise speed.
  - Reduce power to cruise setting.
  - Adjust trim until no force is needed on the control column.
- **Considerations**
- Always read the POH and operation technique for each aircraft.
- Do not attempt to trim during critical phases like takeoff or landing without proper knowledge.
- **Special Circumstances**
- If switching between aircraft types (e.g., Cruiser to Cessna or Piper), review the trim operation procedures specific to each model.

Manually Adjustable Trimmer Tabs

> Some trimmer tabs are only adjustable on the ground and are set for cruise flight, as most time is spent in cruise rather than takeoff or landing.

- **Keypoints**
  - Ground-adjustable trimmer tabs are not adjustable in flight.
  - Set for cruise phase to minimize workload during the longest flight segment.
- **Explanation**
  Since cruise is the longest phase, ground-adjustable tabs are set for optimal performance during this period.
- **Examples**
  > Before flight, adjust the trimmer tab for cruise flight, as it cannot be changed in the air.

  - Mechanic or pilot sets tab on the ground.
  - Tab remains fixed during flight.
  - Optimized for cruise, not takeoff or landing.
- **Considerations**
- Check tab setting during preflight inspection.
- Understand that in-flight adjustment is not possible for these tabs.
- **Special Circumstances**
- If cruise handling is not as expected, check ground-adjustable tab setting before next flight.

Relationship between Trim, Elevator, and Aircraft Pitch

> The trim and elevator work together to control the pitch of the aircraft. When the trim is adjusted, it changes the position of the elevator, which in turn affects the pitching moment and the aircraft's attitude.

- **Keypoints**
  - Trim adjustment changes the elevator's position.
  - A small movement in trim can cause a sensitive change in elevator position.
  - When the elevator moves down, the air hitting it creates a pitching moment.
  - The pitching moment acts between the horizontal stabilizer and the elevator, affecting the whole aircraft.
- **Explanation**
  When the trim is moved, it causes the elevator to change its position. If the elevator moves down, the air hits it and creates a pitching moment that acts on the horizontal stabilizer and elevator, causing the aircraft to pitch down. The relationship is sensitive due to the small surface area of the trim.
- **Examples**
  > If the elevator moves down and stays in place like a wall, the air hitting it creates a pitching moment that causes the tail to go down and the nose to go up.

  - Trim is adjusted, causing the elevator to move down.
  - Airflow hits the elevator, creating a force.
  - This force acts to push the tail down.
  - As the tail goes down, the nose of the aircraft goes up.
- **Considerations**
- Always observe the tip of the elevator to determine the aircraft's pitch response.
- Understand the difference between moving the control column and adjusting trim.
- **Special Circumstances**

- If a student is confused about the relationship between elevator movement and aircraft pitch, use physical demonstrations or models to clarify.

Difference Between Elevator and Flap Effects on Pitch

> Elevators and flaps both affect the pitch of the aircraft, but in different ways. Elevator movement directly changes the aircraft's pitch by altering the tail's position, while flaps change the center of pressure and thus the pitching moment.

- **Keypoints**
  - Elevator movement changes the tail's position, directly affecting pitch.
  - Flap deployment changes the center of pressure, which alters the pitching moment.
  - On high-wing aircraft, extending flaps moves the center of pressure forward, causing a pitching up moment.
  - On low-wing aircraft, extending flaps moves the center of pressure backward, causing a nose-down pitching moment.
- **Explanation**
  When the elevator is moved, it changes the tail's position, which directly affects the aircraft's pitch. Flaps, on the other hand, change the center of pressure on the wing. On high-wing aircraft like the Cessna, extending flaps moves the center of pressure forward, causing the nose to pitch up. On low-wing aircraft like the Bacher, extending flaps moves the center of pressure backward, causing the nose to pitch down.
- **Examples**
  > On a Cessna (high-wing), deploying flaps creates a strong pitching up moment. On a Bacher (low-wing), deploying flaps creates a nose-down pitching moment.

  - Flaps are extended on a Cessna.
  - Center of pressure moves forward.
  - Aircraft experiences a pitching up moment.
  - Flaps are extended on a Bacher.
  - Center of pressure moves backward.
  - Aircraft experiences a nose-down pitching moment.
- **Considerations**
- Understand the configuration of the aircraft (high-wing vs. low-wing) to predict pitching moment.
- Remember that 'lowering' flaps means 'extending' them.
- **Special Circumstances**
- If a student confuses the effects of elevator and flap movement, clarify by discussing the role of center of pressure and direct control surface movement.

Effect of Flap Deployment on Lift and Drag

> Deploying flaps increases both lift and drag. The increase in lift allows for lower takeoff and landing speeds, while the increase in drag requires more power to maintain flight.

- **Keypoints**
    - Flap deployment increases the coefficient of lift.
    - Lift increases moderately with flap extension.
    - Drag increases rapidly with flap extension.
    - More power is needed to compensate for increased drag.
- **Explanation**
  When flaps are deployed, the wing's ability to generate lift increases, allowing the aircraft to fly at lower speeds without stalling. However, drag also increases significantly, so the pilot must use more power to maintain altitude or speed.
- **Examples**
  > With zero flaps, the aircraft has normal lift and low drag. As flaps are extended, drag increases rapidly and lift increases moderately, requiring more power.

    - Pilot extends flaps during approach.
    - Lift increases, allowing slower approach speed.
    - Drag increases, requiring more engine power.
    - Aircraft can land safely at a lower speed.
- **Considerations**
- Always anticipate the need for more power when deploying flaps.
- Monitor airspeed and adjust power accordingly during flap deployment.
- **Special Circumstances**
- If encountering unexpected loss of lift or excessive drag after flap deployment, check for proper flap extension and adjust power as needed.

Movement of Center of Pressure with Flap Extension and Retraction

> The center of pressure moves depending on whether flaps are extended or retracted, and this movement differs between high-wing and low-wing aircraft.

- **Keypoints**
    - On high-wing aircraft, extending flaps moves the center of pressure forward.
    - On low-wing aircraft, extending flaps moves the center of pressure backward.
    - Retracting flaps reverses the movement of the center of pressure.
- **Explanation**
  When flaps are extended on a high-wing aircraft, the center of pressure moves forward, causing a pitching up moment. On a low-wing aircraft, the center of

pressure moves backward, causing a pitching down moment. Retracting the flaps causes the center of pressure to move in the opposite direction for each configuration.

- **Examples**

  > In the exam, students may be asked what happens to the center of pressure when flaps are lowered (extended) or retracted on high-wing and low-wing aircraft.

  - Flaps are lowered (extended) on a high-wing aircraft: center of pressure moves forward.
  - Flaps are lowered (extended) on a low-wing aircraft: center of pressure moves backward.
  - Flaps are retracted on a high-wing aircraft: center of pressure moves backward.
  - Flaps are retracted on a low-wing aircraft: center of pressure moves forward.
- **Considerations**
- Clarify terminology: ‘lowering’ flaps means ‘extending’ them.
- Be aware of aircraft configuration when predicting center of pressure movement.
- **Special Circumstances**
- If students are confused by terminology, provide clear definitions and examples.

Types and Effects of Flaps

> Different types and designs of flaps (plain, split, slotted, Fowler, Fowler and slotted) provide varying increases in the maximum coefficient of lift (CLmax) and have different effects on drag and stall characteristics.

- **Keypoints**
  - Plain (simple) flap: increases CLmax by 50%.
  - Split flap: increases CLmax by up to 60%, creates more drag than plain flap.
  - Slotted flap: increases CLmax by up to 70%, features a gap that re-energizes airflow and delays stall.
  - Fowler flap: increases CLmax by up to 100%, moves down and to the side.
  - Fowler and slotted flap: increases CLmax by up to 120%, combines Fowler movement and slot gap.
  - Flap deployment reduces stalling speed and causes stall at a shallower angle of attack (e.g., from 15 degrees to 5 degrees).
- **Explanation**

  Each flap type modifies the wing’s lift and drag characteristics differently. Plain flaps hinge downward, split flaps separate from the trailing edge, slotted flaps have a gap for airflow, Fowler flaps extend and move back, and Fowler-slotted combine both. Deploying flaps allows flight at lower speeds and reduces the stalling angle of attack.

- **Examples**
  > In exams, students may be asked: ‘What is the percentage increase in CLmax for a plain type of flap?’ The answer is 50%.

  - Plain flaps hinge downward and increase the maximum coefficient of lift by 50%.
  - This is a key fact to remember for exams.

  > Fowler and slotted flaps are used in larger jets because they provide up to 120% increase in CLmax, which is necessary for heavy aircraft to maintain sufficient lift at lower speeds.

  - Large jets require more lift due to their weight.
  - Fowler and slotted flaps provide the highest increase in CLmax, making them suitable for these aircraft.
- **Considerations**
- Remember the specific percentage increases for each flap type.
- Understand that deploying flaps reduces stalling speed and angle of attack.
- Be aware that split flaps create more drag than plain flaps.
- **Special Circumstances**
- If flaps are deployed asymmetrically, the airplane will roll toward the wing with less flap deflection and may yaw away from the wing with less drag. Apply opposite aileron and substantial opposite rudder to counteract.

Flap Asymmetry and Mnemonic LOI

> Flap asymmetry occurs when flaps do not deploy symmetrically, leading to roll and yaw. The mnemonic LOI (Limitation, Operation, Indication) is used to prevent and check for asymmetry.

- **Keypoints**
  - Limitation: Check airspeed is below or just below VFE before deploying flaps.
  - Operation: Operate the flap lever to deploy flaps.
  - Indication: Check that flaps are operating symmetrically by visual inspection and cockpit indicators.
  - If asymmetry occurs, the airplane will roll toward the wing with less flap deflection and may yaw away from the wing with less drag.
- **Explanation**
  LOI helps pilots systematically check for safe flap operation. If asymmetry is detected, corrective action involves applying opposite aileron and rudder. Feeling the aircraft’s response after deploying flaps can also indicate symmetry.
- **Examples**

> If the left flap detaches, there is less lift on the left wing, causing the aircraft to roll left. The pilot should apply opposite aileron and rudder.

  - Loss of left flap reduces lift on the left wing.
  - Aircraft rolls left; pilot counters with right aileron and rudder.
- **Considerations**
- Always check airspeed before deploying flaps.
- Visually confirm flap symmetry when possible.
- Be aware that solo flight makes visual checks more difficult.
- **Special Circumstances**
- If flap asymmetry is experienced in flight, apply opposite aileron and rudder, and consider side-slipping during approach.

Slats and Slots (Leading Edge Devices)

> Slats and slots are leading edge devices (LEDs) that increase lift near stall by allowing high-pressure air from beneath the wing to flow over the upper surface, re-energizing the flow and delaying separation.

- **Keypoints**
  - Slats and slots increase CLmax by 50% to 60%.
  - They allow the wing to stall at a higher angle of attack (e.g., from 10 degrees to 15 degrees).
  - A slot is a fixed gap in the leading edge; a slat is a movable section that creates the slot.
  - Used primarily in larger jets for efficiency.
- **Explanation**
  Slats move forward to create a slot, allowing airflow from below to energize the upper surface, delaying stall. Slots are fixed gaps. Both devices increase maximum lift and stall angle.
- **Examples**
  > In diagrams, the slat is the device itself, and the slot is the gap between the slat and the wing.

  - Slat: movable leading edge device.
  - Slot: gap created by slat movement.
- **Considerations**
- General aviation aircraft typically do not use slats and slots.
- Larger jets use these devices for maximum efficiency.

Spoilers

> Spoilers are devices on the upper wing surface that reduce lift when deployed. Used symmetrically, they reduce lift; used asymmetrically, they assist in roll control.

- **Keypoints**
  - Spoilers reduce lift when deployed symmetrically.
  - When used asymmetrically, spoilers assist in rolling the aircraft.
  - Spoilers are visible on large jets during takeoff and landing.
  - Spoilers are also called airbrakes or lift-dumpers.
- **Explanation**
  Spoilers disrupt airflow over the wing, reducing lift. On large jets, spoilers deploy during landing to kill lift and help slow the aircraft. Asymmetric deployment aids roll control, especially at lower speeds.
- **Examples**
  > Glider pilots deploy air brakes (spoilers) when 5 or 10 feet above the ground to kill lift and prevent floating or ballooning during landing.

  - Deploying spoilers reduces lift, allowing the glider to settle onto the runway.
- **Considerations**
- Spoilers are not typically used in general aviation aircraft.
- On large jets, spoilers are used for both lift reduction and roll control.

Boundary Layer and Flow Types

> The boundary layer is the thin layer of air in contact with the wing surface, where velocity increases from zero at the surface to the free stream value. Laminar flow is smooth and parallel; turbulent flow is mixed. The transition point is where laminar flow becomes turbulent.

- **Keypoints**
  - Boundary layer is only a few millimeters thick.
  - Velocity is lowest at the surface due to friction drag and viscosity.
  - Laminar flow: smooth, parallel vectors.
  - Turbulent flow: mixed, non-parallel vectors.
  - Transition point: where laminar flow becomes turbulent.
- **Explanation**
  Air particles closest to the wing move slowest due to friction. As distance from the surface increases, velocity increases until it matches the free stream. Laminar flow is orderly; turbulent flow is chaotic. The transition point marks the change.
- **Examples**
  > A diagram shows air particles moving over a wing, with velocity increasing away from the surface. The boundary layer is the region of velocity increase.

- Particles at the surface: lowest speed.
  - Particles further away: higher speed.
  - Boundary layer: region of velocity gradient.
- **Considerations**
- Boundary layer thickness and behavior affect lift and drag.
- Understanding flow types is essential for aerodynamic analysis.

Bernoulli’s Principle and Pressure Distribution

> Bernoulli’s principle states that where the velocity of airflow is highest, the pressure is lowest. This principle explains lift generation over a wing.

- **Keypoints**
  - Maximum curvature of the wing corresponds to highest airflow speed and lowest pressure.
  - Dynamic pressure increases as velocity increases; static pressure decreases.
  - Air moves naturally from high to low pressure regions.
- **Explanation**
  As air flows over the wing, it speeds up over the curved upper surface, reducing pressure and generating lift. The difference in pressure above and below the wing creates upward force.
- **Considerations**
- Understanding pressure distribution is key to understanding lift and stall.

Stall and Stall Characteristics

> A stall occurs when the wing no longer generates lift due to airflow separation. Deploying flaps reduces the stalling speed and angle of attack.

- **Keypoints**
  - Stall: no more airflow over the wing, no lift generated.
  - Deploying flaps allows flight at lower speeds and reduces stalling angle of attack (e.g., from 15 degrees to 5 degrees).
- **Explanation**
  When the angle of attack exceeds a critical value, airflow separates from the wing, causing a stall. Flaps allow the aircraft to stall at lower speeds and shallower angles.
- **Considerations**
- Monitor airspeed and angle of attack to avoid stall.
- Deploying flaps changes stall characteristics.

Turbulent and Laminar Airflow over Wings

> Turbulent air is more energetic than laminar air and adheres better to the wing surface. The transition point is where laminar flow becomes turbulent. The separation point is where airflow leaves the wing surface, leading to increased drag.

- **Keypoints**
  - Turbulent air is very energetic and sticks to the wing better than laminar air.
  - Transition point: where laminar flow converts to turbulent flow.
  - Separation point: where turbulent air separates from the wing.
  - Separated airflow increases drag, especially induced drag due to downwash.
- **Explanation**
  Turbulent air, compared to laminar, has higher energy and thus adheres to the wing surface more effectively. The transition point marks the change from laminar to turbulent flow, while the separation point is where the airflow detaches from the wing, causing increased drag and downwash.
- **Considerations**
- Understanding the difference between transition and separation points is crucial for aerodynamic analysis.

Effect of Angle of Attack on Wing Aerodynamics

> Increasing the angle of attack changes the pressure distribution on the wing, moving the center of pressure forward until the critical angle is reached, after which it moves backward. The coefficient of lift (CL) reaches a maximum at the critical angle, and the coefficient of drag (CD) increases with angle of attack.

- **Keypoints**
  - As angle of attack increases, center of pressure moves forward.
  - At critical angle of attack (critical alpha), maximum lift is achieved and the wing stalls.
  - After critical angle, center of pressure moves backward.
  - Coefficient of drag (CD) increases with angle of attack.
- **Explanation**
  When the angle of attack increases, the pressure distribution on the wing changes, causing the center of pressure to move forward. At the critical angle, maximum lift is achieved, but further increase causes stall and the center of pressure moves backward. The coefficient of drag increases with angle of attack.
- **Considerations**
- Monitor angle of attack to avoid exceeding the critical angle and stalling.

Wing Planform and Stall Characteristics

> Different wing shapes (planforms) affect how and where stall occurs. On swept wings, the tip stalls first, which can be dangerous if ailerons are located at the tip. On straight wings, the root stalls first, preserving aileron control.

- **Keypoints**
    - Swept wings: tip stalls first, risking loss of aileron control.
    - Straight wings: root stalls first, maintaining aileron control.
    - Washout: design feature to ensure root stalls before tip.
- **Explanation**
  The stall progression depends on wing planform. Swept wings stall at the tip first, which can cause loss of roll control. Straight wings stall at the root first, allowing for recovery. Washout is used to ensure the root stalls before the tip.
- **Examples**
  > At the wing root, the angle of incidence is 1.5 degrees; at the wing tip, it is -1 degree. When the angle of attack increases, the root reaches the critical angle before the tip, causing the root to stall first.

    - The wing root is tilted upward (1.5°), the tip is tilted downward (-1°).
    - As angle of attack increases, the root meets the airflow at a greater angle than the tip.
    - The root stalls first, preserving control at the tip.
- **Considerations**
- Aileron placement is critical for stall recovery.
- Washout design improves safety and control during stall.
- **Special Circumstances**
- If encountering a stall on a swept wing with ailerons at the tip, aileron control may be lost, increasing danger.
- If the aircraft is not certified for spins (e.g., cruiser), intentional spins must be avoided.

Boundary Layer Separation and Stall

> As the angle of attack increases, the flow in the boundary layer stops and reverses direction, causing boundary layer separation. When separation moves forward enough, the wing stalls and further increases in angle of attack reduce lift.

- **Keypoints**
    - Boundary layer separation occurs as angle of attack increases.
    - Separation point moves forward as angle increases.
    - Stall occurs when separation disrupts lift generation.
- **Explanation**
  Increasing angle of attack causes the boundary layer to separate from the wing

surface, moving the separation point forward. When this disrupts the airflow enough, the wing stalls and lift decreases.
- **Considerations**
- Monitor angle of attack to prevent boundary layer separation leading to stall.

Slow Flight and Power Required Curve

> Slow flight involves reducing airspeed to near stall speed (e.g., 30–40 knots in cruiser) with flaps deployed. At speeds below the minimum power required, further speed reduction requires more power to maintain level flight due to increased induced drag.

- **Keypoints**
  - Slow flight: airspeed reduced to 30–40 knots in cruiser, with flaps in takeoff or landing position.
  - At speeds below minimum power required, decreasing airspeed requires more power.
  - Induced drag increases as angle of attack increases in slow flight.
  - Power required equals drag multiplied by airspeed.
- **Explanation**
  During slow flight, the aircraft is flown at low airspeed, close to stall, requiring increased angle of attack and more power to maintain altitude. The power required curve shows that below a certain speed, more power is needed as speed decreases.
- **Considerations**
- In slow flight, maintain specified speed and altitude with increased power.
- Be aware that induced drag increases as speed decreases below minimum power required.
- **Special Circumstances**
- If practicing slow flight in a simulator, it may be harder to demonstrate the power curve effects than in real flight.

Effects of Slipping and Skidding on Stall

> Slipping and skidding affect airflow over the wings and can influence stall characteristics. In a slip, the lower wing may retain laminar flow; in a skid, the airflow may hit the nose and affect the low wing differently, potentially leading to a spin.

- **Keypoints**
  - Slipping: lower wing may retain laminar flow.

- Skidding: airflow may hit the nose and affect the low wing, increasing risk of spin.
- Side-slipping should be avoided when solo.

- **Explanation**
  During a slip, the aircraft's lower wing may maintain laminar flow, while in a skid, the airflow pattern can increase the risk of entering a spin. Side-slipping is generally avoided when flying solo for safety.
- **Considerations**
- Be cautious with side-slipping, especially when solo.
- Understand the difference between slip and skid effects on stall.
- **Special Circumstances**
- If entering a skid, there is a higher risk of spin; avoid side-slipping when solo.

Relationship between Pitch and Airspeed

> To increase airspeed, the pilot must decrease pitch. Maintaining the same pitch while accelerating will cause the aircraft to gain altitude. Therefore, when increasing speed, pitch should be decreased.

- **Keypoints**
  - Increasing airspeed with constant pitch leads to altitude gain.
  - To increase speed, decrease pitch.
  - Pitch adjustments are essential for speed control.
- **Explanation**
  When the pilot wants to increase airspeed, simply adding power without adjusting pitch will cause the aircraft to climb. To maintain level flight and increase speed, the pilot must lower the nose (decrease pitch).
- **Considerations**
- Always adjust pitch when changing airspeed to avoid unintended altitude changes.

Control Forces and Airspeed

> At lower airspeeds, control forces decrease because there is less airflow over the control surfaces (aileron, elevator, rudder). This makes the controls feel less effective and requires larger control movements.

- **Keypoints**
  - Lower airspeed means less dynamic pressure on control surfaces.
  - Controls become less responsive and require more movement.
  - Aircraft handling becomes sluggish at low speeds.
- **Explanation**
  As airspeed decreases, the amount of airflow over the control surfaces reduces,

making them less effective. Pilots must use larger inputs to achieve the same effect, and there is a delay in aircraft response.

- **Considerations**
- Expect sluggish controls at low speeds.
- Be prepared for delayed aircraft response.
- **Special Circumstances**
- If experiencing sluggish controls at low speed, anticipate the need for larger and more deliberate control inputs.

Slipstream, Asymmetric Flight Effect, and Torque Effect at Low Speeds

> At low speeds and high power, slipstream, asymmetric flight effect, and torque effect become more pronounced, requiring more rudder input to maintain balance.

- **Keypoints**
  - Slipstream effect increases at low speeds with high power.
  - Asymmetric flight and torque effects can cause the aircraft to roll or yaw.
  - More rudder input is needed to maintain coordinated flight.
- **Explanation**
  When flying slowly with high power, the propeller’s slipstream wraps around the fuselage and hits the tail, causing yaw. Asymmetric thrust and torque can also cause rolling or yawing tendencies, requiring the pilot to use more rudder.
- **Considerations**
- Monitor aircraft balance closely at low speeds and high power.
- Be ready to use more rudder input.
- **Special Circumstances**
- If the aircraft starts to roll or yaw unexpectedly at low speed and high power, apply appropriate rudder to maintain balance.

Aileron Drag and Adverse Yaw

> At low speeds, aileron deflection produces more noticeable aileron drag and adverse yaw, making coordinated turns more challenging.

- **Keypoints**
  - Aileron drag increases at low speeds.
  - Adverse yaw becomes more pronounced.
  - Coordinated use of rudder is essential during turns.
- **Explanation**
  When rolling into or out of a turn at low speed, the increased drag from the downward-deflected aileron causes the nose to yaw in the opposite direction of the turn. Pilots must use rudder to counteract this effect.

- **Considerations**
- Always use coordinated rudder and aileron at low speeds.

Stall and Deep Stall Phenomena

> A stall occurs when the airflow separates from the wing, causing loss of lift. In some aircraft, especially with certain tail configurations, a deep stall or super stall can occur, where the horizontal stabilizer also loses airflow, making recovery extremely difficult or impossible.

- **Keypoints**
  - Stall: airflow separates from the wing.
  - Deep stall: airflow also separates from the horizontal stabilizer.
  - Deep stall recovery is nearly impossible in 99% of cases for some aircraft.
- **Explanation**
  In a deep stall, the tailplane is blanketed by turbulent airflow from the stalled wing, preventing it from regaining lift. This can lead to uncontrollable descent.
- **Examples**
  > The Tupolev 154, a Soviet Union aircraft, experienced a deep stall a long time ago. The crew could not recover from the stall, even with full control deflections, and the aircraft continued to descend uncontrollably.

  - The aircraft entered a super stall due to its design.
  - Both the wing and horizontal stabilizer lost airflow.
  - Recovery was impossible despite all control inputs.
- **Considerations**
- Be aware of aircraft type and susceptibility to deep stall.
- Understand that some stalls may be unrecoverable in certain aircraft.
- **Special Circumstances**
- If encountering a deep stall in an aircraft with a conventional empennage, recovery may be possible, but in T-tail or certain designs, recovery may be impossible.

Stall Recovery Procedure

> To recover from a stall, reduce the angle of attack by pushing the control column, increase power to arrest the descent, and gently return to normal flight.

- **Keypoints**
  - First, reduce angle of attack by pushing forward.
  - Rate of descent will increase initially.
  - Increase power to reduce descent rate.
  - Gently recover to level flight.

- **Explanation**
  When approaching or entering a stall, the pilot must lower the nose to reduce the angle of attack, apply power to regain lift, and carefully return to normal flight without over-controlling.
- **Considerations**
- Avoid over-pulling or over-pushing the yoke during recovery.
- Monitor speed and altitude closely during recovery.
- **Special Circumstances**
- If the aircraft does not recover from a stall after standard procedures, check for deep stall or other abnormal conditions.

Airspeed Indicator Arcs and V-Speeds

> The airspeed indicator has colored arcs representing different speed ranges: white (flap extension), green (normal operation), yellow (caution/temporary), and red (never exceed). VSO is stall speed in landing configuration; VS1 is stall speed in clean configuration.

- **Keypoints**
  - White arc: flap extension speed.
  - Green arc: normal operation.
  - Yellow arc: caution/temporary operation (smooth air only).
  - Red line: never exceed speed.
  - VSO: stall speed with flaps down.
  - VS1: stall speed with flaps up (clean).
- **Explanation**
  Pilots use the colored arcs to quickly identify safe operating speeds for different configurations. VSO and VS1 are critical for understanding stall margins.
- **Considerations**
- Do not exceed speeds in the yellow arc except in smooth air.
- Never exceed the red line speed.

Effect of Flaps on Stall Speed

> Deploying flaps lowers the stall speed, while retracting flaps increases the stall speed. For example, with flaps down, stall speed may be 60 knots; with flaps up, it may be 65 knots.

- **Keypoints**
  - Flaps down: stall speed decreases.
  - Flaps up: stall speed increases.
  - Stall speed changes are visible on the airspeed indicator.

- **Explanation**
  Flaps increase the wing's lift at lower speeds, allowing the aircraft to fly slower before stalling. Retracting flaps reduces lift and increases stall speed.
- **Considerations**
- Be aware of stall speed changes when configuring flaps during approach and landing.

Typical Landing Speeds and Stall Margins

> During landing, pilots fly at speeds above stall speed to maintain a safety margin. For example, on the cruiser, stall speed with flaps down is 31 knots, and typical landing speed is 65 knots, providing a margin of 34 knots.

- **Keypoints**
  - Landing speeds are set above stall speed for safety.
  - Strong headwinds can result in very low or even negative ground speed.
  - Always maintain a safe margin above stall speed.
- **Explanation**
  Flying at a speed significantly above stall speed during landing ensures controllability and safety, even in variable wind conditions.
- **Examples**
  > A pilot in a strong headwind reduced airspeed so much that ground speed was negative, at minus one and minus four knots, causing the aircraft to move backwards relative to the ground.

  - Strong headwind can reduce ground speed below zero if airspeed is close to stall.
  - This is not recommended except under instructor supervision.
- **Considerations**
- Do not attempt extremely low or negative ground speeds except under instructor supervision.
- **Special Circumstances**
- If ground speed becomes negative due to strong headwind, maintain safe airspeed and avoid stalling.

Effect of Mass on Stall Speed

> Increasing aircraft mass increases stall speed. Heavier aircraft require more lift to stay airborne, which requires higher speed.

- **Keypoints**
  - Higher mass = higher stall speed.
  - Boeing 737 has higher stall speed than a light aircraft due to greater mass.

- **Explanation**
  As mass increases, the aircraft must generate more lift to support the weight, which can only be achieved at a higher speed, thus increasing stall speed.
- **Considerations**
- Account for increased stall speed when operating at higher weights.

Effect of Load Factor on Stall Speed

> Stall speed increases with load factor. For example, at 1G, stall speed is 50 knots; at 2G, 70 knots; at 3G, 86 knots. Load factor is the ratio of lift to weight.

- **Keypoints**
  - Higher load factor (e.g., in turns) increases stall speed.
  - Stall speed for 1G is Vs1g.
  - Stall speed increases with acceleration (G-force).
- **Explanation**
  When the aircraft is subjected to higher load factors, such as in steep turns, the wings must generate more lift, requiring higher speed to avoid stalling.
- **Considerations**
- Be cautious of increased stall speed during steep turns or maneuvers.

Formula for Load Factor in Turns

> The load factor in a turn is calculated as 1 divided by the cosine of the bank angle (in degrees). For example, at 60 degrees bank, load factor is 2G; at 70 degrees, it is 3G.

- **Keypoints**
  - Load factor = 1 / cos(bank angle).
  - 60° bank: 2G; 70° bank: 3G.
- **Explanation**
  As the bank angle increases, the load factor increases rapidly, which in turn increases stall speed.
- **Considerations**
- Monitor bank angle and corresponding load factor to avoid inadvertent stalls.

Effect of Power on Stalling Speed

> Increasing power decreases stalling speed due to the upward thrust vector aiding lift and re-energizing airflow over the wing.

- **Keypoints**
  - When power is increased, the thrust vector acts upward, assisting the lift vector.

- Re-energizing airflow at the wing delays separation, reducing stalling speed.
    - Drag does not play a direct role in stall in this context.
- **Explanation**
  When power is increased, the propeller's thrust vector has an upward component, which adds to the lift produced by the wings. Additionally, increased power re-energizes the airflow over the wing, especially on straight wings, delaying the separation of airflow and thus reducing the stalling speed.
- **Examples**
  > The instructor asks: 'What's going to happen when I'm going to increase the power? The stalling speed is going to increase or decrease?' The answer is decrease, because of the upward thrust vector and re-energized airflow.

    - Student answers 'increase', instructor corrects to 'decrease'.
    - Explains thrust vector and airflow re-energization.
- **Considerations**
- Do not confuse drag with the effect of power on stall.
- Remember that increased power reduces stalling speed.

Effect of Flaps on Stalling Speed

> Deploying or lowering flaps decreases stalling airspeed, allowing the aircraft to fly slower before stalling.

- **Keypoints**
    - Flaps increase CLmax and allow for a shallower stalling angle.
    - With flaps extended, the aircraft can fly at a lower airspeed before stalling.
- **Explanation**
  Lowering flaps increases the maximum coefficient of lift (CLmax), which means the wing can generate more lift at a lower speed. This allows the aircraft to fly slower before reaching the stalling angle of attack.
- **Considerations**
- Monitor airspeed indicator when deploying flaps.
- Be aware of altered lift distribution with flaps.

Effect of Center of Gravity on Stalling Speed

> Moving the center of gravity forward increases stalling airspeed.

- **Keypoints**
    - Forward CG increases stalling speed.
    - Explanation provided later in the lecture.

- **Explanation**
  A forward center of gravity requires a higher angle of attack to maintain level flight, which increases the stalling speed.
- **Considerations**
- Be aware of CG position during loading and flight.

Wing Contamination and Stalling Speed

> Contaminants such as ice, frost, or damage on the wing increase stalling speed.

- **Keypoints**
  - Contaminated wings increase stalling speed.
  - Contamination includes ice, frost, or physical damage.
- **Explanation**
  Contaminants disrupt smooth airflow over the wing, reducing lift and increasing the speed at which the wing will stall.
- **Considerations**
- Always check for wing contamination before flight.
- **Special Circumstances**
- If encountering wing contamination, how should it be addressed? Remove contamination before flight to ensure safe stalling characteristics.

Symptoms and Warning Signs of Stall

> Recognizing stall symptoms is critical for safe flight. Symptoms include abnormally slow airspeed, ineffective controls, unusual quietness, stall warning activation, high rate of descent, and nose-down pitching moment (G-brake).

- **Keypoints**
  - Abnormally slow airspeed for the maneuver.
  - Sloppy or ineffective flying controls.
  - Unusual quietness in the cockpit.
  - Stall warning system activation (light and sound).
  - High rate of descent and nose-down pitching moment.
  - Possible vibration (bucket) on larger aircraft.
- **Explanation**
  Pilots must be able to recognize these symptoms to take corrective action before a full stall develops. The G-brake is a nose-down pitching moment that occurs on a straight wing when stalled.
- **Considerations**
- Practice recognizing stall symptoms during training.
- Be alert for high rate of descent and nose-down pitching.

Quasi-Stall (Semi-Stall) Phenomenon

> A quasi-stall or semi-stall occurs when the wings are technically stalled, but the aircraft remains controllable and continues to descend at a high rate.

- **Keypoints**
  - Angle of attack is higher than the stalling angle.
  - Aircraft is still flying but descending rapidly.
  - Some control is retained.
- **Explanation**
  In a quasi-stall, the aircraft exceeds the stalling angle of attack but does not lose all control authority. The pilot can still maneuver, but the descent rate is high.
- **Considerations**
- Recognize quasi-stall conditions and recover promptly.

Stall Recovery Procedures

> Proper stall recovery involves reducing the angle of attack by pushing the control column forward and then increasing power to arrest the rate of descent.

- **Keypoints**
  - First, reduce angle of attack (push control column forward).
  - Second, increase power.
  - Be quick with recovery, especially near the ground.
- **Explanation**
  To recover from a stall, the pilot must lower the nose to reduce the angle of attack below the critical value, then add power to stop descending. Quick recovery is essential at low altitude.
- **Examples**
  > Instructor emphasizes the need for fast recovery if close to the ground, as failure to recover quickly can result in a crash.

  - Push control column forward.
  - Add power.
  - Recover before losing too much altitude.
- **Considerations**
- Practice stall recovery with instructors and solo.
- React quickly if stall occurs near the ground.
- **Special Circumstances**
- If encountering a stall close to the ground, how should it be addressed? Immediate recovery actions must be taken: reduce angle of attack and add power without delay.

Angle of Attack and Stall

> The angle of attack is the angle between the wing chord and the aircraft's flight path. Stall occurs when the angle of attack exceeds the critical value, regardless of aircraft attitude.

- **Keypoints**
  - Angle of attack increases as aircraft pitches down during stall.
  - Altitude is not the same as angle of attack.
  - Reducing angle of attack is necessary for recovery.
- **Explanation**
  Even if the aircraft is nose-down, the angle of attack can remain high if the flight path is steep. Recovery requires actively reducing the angle of attack.
- **Considerations**
- Monitor angle of attack, not just attitude.

Approach and Landing Procedures (Runway 04 Example)

> Proper approach to runway 04 involves entering downwind, turning base (90 degrees), and then turning final (another 90 degrees). The most dangerous regions are the turns to base and final.

- **Keypoints**
  - Enter downwind, turn base 90°, then final 90°.
  - Turns to base and final are high-risk for stall/spin.
  - Aircraft imbalance and low airspeed increase risk.
- **Explanation**
  During approach, especially in turns, improper coordination or low airspeed can lead to a stall and possible spin. Maintaining balance and adequate airspeed is critical.
- **Examples**
  > Instructor describes the approach path and highlights the danger zones during the base and final turns.

  - Enter downwind.
  - Turn base 90°, then final 90°.
  - Monitor airspeed and balance to avoid stall/spin.
- **Considerations**
- Be vigilant during base and final turns.
- Keep aircraft balanced and maintain safe airspeed.
- **Special Circumstances**
- If encountering a wing drop during approach, how should it be addressed? Use rudder to correct, avoid aileron input that could worsen the stall.

Aileron Use and Wing Drop During Stall

> Improper use of ailerons during a stall can worsen the situation, causing the aircraft to enter a spin. The aileron can locally increase the angle of attack and stall the wing.

- **Keypoints**
  - Aileron input during stall can cause counter-roll.
  - Full aileron deflection may stall the wing further.
  - Opposite aileron input can worsen the spin.
- **Explanation**
  When the aircraft is stalled, using ailerons to level the wings can increase the angle of attack on the already stalled wing, causing a spin. Rudder should be used instead.
- **Examples**
  > A student pilot applies full aileron deflection during a stall, causing the aircraft to enter a spin. The instructor takes control and recovers.

  - Student tries to level wings with ailerons.
  - Aircraft enters spin due to increased angle of attack.
  - Instructor recovers using proper technique.
- **Considerations**
- Avoid aileron input during stall recovery.
- Use rudder to correct wing drop.
- **Special Circumstances**
- If encountering a wing drop during stall, how should it be addressed? Use rudder to correct roll, not ailerons.

Use of Rudder to Prevent/Control Wing Drop

> Rudder is the primary control for correcting wing drop during a stall. Applying opposite rudder can prevent or recover from a spin.

- **Keypoints**
  - Rudder corrects roll caused by wing drop.
  - Pedal control is essential during stall recovery.
  - Instructor demonstrates flying with pedals only.
- **Explanation**
  When a wing drops during a stall, applying opposite rudder (not aileron) can level the wings and prevent a spin. Pedal control is critical.
- **Examples**
  > Instructor tells student to fly using only pedals to prevent stall and wing drop.

    - Student releases control column.
    - Uses pedals to maintain balance and prevent stall.
- **Considerations**
- Practice rudder control during stall training.
- Do not rely on ailerons during stall recovery.

Effect of Flaps and Yaw on Wing Drop

> Lowered flaps and significant yaw at the stall make wing drop more likely due to altered lift distribution and slower stall speed.

- **Keypoints**
    - Flaps alter lift distribution, increasing wing drop risk.
    - Yaw at stall contributes to wing drop.
- **Explanation**
  Flaps change the lift characteristics across the wing, and yaw can cause one wing to stall before the other, leading to a wing drop.
- **Considerations**
- Keep aircraft in balance with pedals/feet.
- Monitor yaw and avoid uncoordinated flight.

Stalling in Turns and Outer Wing Stall

> In a low turn, the upper (outer) wing has a higher angle of attack and usually stalls first, leading to a wing drop.

- **Keypoints**
    - Outer wing in a turn has higher angle of attack.
    - Outer wing stalls first, causing wing drop.
- **Explanation**
  During a turn, the outer wing travels faster and at a higher angle of attack. If the critical angle is exceeded, the outer wing stalls first, causing the aircraft to roll and possibly spin.
- **Considerations**
- Be cautious during low-altitude turns.
- Monitor angle of attack and airspeed in turns.

Stall Warning Systems and Regulations

> Stall warning systems must operate at least 5 knots or 5% above the stalling speed, whichever is greater, and continue until stall occurs. Regulations require stall warning to activate in advance for pilot action.

- **Keypoints**
  - Stall warning operates at >5 knots or >5% above stall speed.
  - Must continue until stall occurs.
  - Take-off and landing speeds must be at least 1.2 times stall speed.
  - Stall warning must activate in turns in time for pilot action.
- **Explanation**
  Stall warning systems are designed to alert the pilot before the aircraft reaches the critical angle of attack. Regulatory requirements ensure adequate warning margin for safe operation.
- **Considerations**
- Check stall warning system during preflight.
- Do not rely solely on airspeed indicator for stall warning.
- **Special Circumstances**
- If stall warning system is inoperative, how should it be addressed? Do not fly until the system is repaired and operational.

Leading Edge Stall Strips and Their Function

> Leading edge stall strips are metallic strips attached to the wing's leading edge to make the airplane stall before the critical angle of attack is reached, improving predictability and controllability.

- **Keypoints**
  - Stall strips cause stall before critical angle.
  - Improve stall predictability and controllability.
  - Prevent uncontrollable stall beyond critical angle.
- **Explanation**
  Stall strips disrupt airflow at a specific point, causing the wing to stall in a controlled manner before reaching the critical angle, making stall behavior more predictable.
- **Examples**
  > Instructor compares stall strips to a guard at a cliff, preventing the pilot from going over the edge (critical angle).

  - Stall strips act as a warning and control measure.
  - Prevent exceeding critical angle of attack.
- **Considerations**
- Inspect stall strips during preflight.

Real-World Stall Accident Scenarios

> Several real-world accidents are described, including steep turns at low altitude, loss of control after take-off, and aerobatic maneuvers leading to stall and crash.

- **Keypoints**
  - Steep turn at low altitude leading to ground impact.
  - Loss of control during turn at 200ft after take-off.
  - Loss of control while maneuvering near a village.
  - Steep climb and turn at 200ft resulting in crash.
  - Aerobatic maneuvers increasing load factor and stall risk.
- **Explanation**
  These scenarios highlight the dangers of low-altitude maneuvering, improper recovery techniques, and the impact of load factor on stall speed.
- **Examples**
  > Aircraft entered a steep climb and turn at about 200ft after take-off, stalled, and crashed.

  - Low altitude left no room for recovery.
  - Possible pilot error or weather factors involved.
- **Considerations**
- Avoid steep turns and climbs at low altitude.
- Consider weather and gusts before take-off.
- **Special Circumstances**
- If encountering unexpected gusts or weather, how should it be addressed? Delay or cancel take-off to ensure safety.

Load Factor and Accelerated Stall

> Increased load factor during maneuvers or aerobatics raises the stall speed, making accelerated stalls more likely.

- **Keypoints**
  - Load factor increases during aerobatics.
  - Stall speed increases with load factor.
  - Sudden pull-up can exceed critical angle and cause stall.
- **Explanation**
  When the aircraft is subjected to higher load factors (e.g., during sharp turns or aerobatics), the wing must support more weight, increasing the stall speed and risk of accelerated stall.
- **Examples**
  > Aircraft attempted a loop at 500-600ft, flipped while descending, and struck the ground almost vertically.

  - High load factor increased stall speed.
  - Insufficient altitude for recovery.

- **Considerations**
- Be aware of increased stall speed during high-G maneuvers.
- Do not attempt aerobatics at low altitude.

Take-off and Landing Speed Regulations

> Take-off and landing speeds must not be less than the stall speed with flaps retracted, and at 50 meters or 50 feet, must be at least 1.2 times the stall speed.

- **Keypoints**
  - Take-off/landing speed ≥ 1.2 × stall speed.
  - Ensures margin above stall during critical phases.
- **Explanation**
  Regulations require a safety margin above stall speed during take-off and landing to prevent inadvertent stalls.
- **Considerations**
- Calculate and adhere to minimum take-off and landing speeds.

Accelerated Stall

> An accelerated stall is a stall that occurs at an acceleration greater than 1G, such as 2Gs, 3Gs, or 4Gs. It typically happens when the aircraft is subjected to increased load factors, such as during abrupt maneuvers or aerobatics, especially at low altitude.

- **Keypoints**
  - Occurs at load factors greater than 1G (e.g., 2Gs, 3Gs, 4Gs).
  - Can happen during aerobatic maneuvers, especially if performed at low altitude.
  - Increased roll factor and pulling can lead to accelerated stall.
  - Practicing aerobatics at a safe altitude is essential to allow room for recovery.
- **Explanation**
  Accelerated stalls occur when the aircraft is maneuvered such that the load factor exceeds 1G, increasing the stalling speed. For example, pulling hard in a turn or during aerobatics increases the load factor, and if the airspeed is not sufficient for the new higher stall speed, the aircraft will stall. Practicing at higher altitudes provides more time and space to recover from such stalls.
- **Examples**
  > An aerobatic maneuver performed at low level resulted in an accelerated stall due to increased roll factor and pulling, causing the aircraft to stall.

  - The pilot increased the load factor by pulling during a maneuver.
  - The aircraft's stall speed increased due to the higher load factor.
  - At low altitude, there was insufficient room to recover, resulting in a crash.

- **Considerations**
- Always practice aerobatics at a safe altitude.
- Be aware of increased stall speeds at higher load factors.
- **Special Circumstances**
- If performing aerobatics at low altitude, how should it be addressed? Avoid such maneuvers and always ensure sufficient altitude for recovery.

Departure Stall (Power-On Stall)

> A departure stall, also known as a power-on stall, occurs during climb shortly after takeoff, typically when the aircraft is not at idle power and is close to maximum takeoff weight. It can be caused by improper flap retraction or loss of control after engine failure.

- **Keypoints**
  - Occurs during climb after takeoff, with power applied.
  - Often happens near maximum takeoff weight.
  - Raising flaps too early or at too low airspeed increases risk.
  - Loss of control after engine failure can lead to stall and crash.
  - Pilot may ‘fall behind the aircraft’ by not monitoring parameters.
- **Explanation**
  Departure stalls are dangerous because they occur close to the ground, leaving little time for recovery. Raising flaps before reaching a safe airspeed increases the stalling speed, and if power is reduced unexpectedly, the stall speed increases further. Pilots must monitor airspeed, keep wings level, and avoid abrupt maneuvers during climb.
- **Examples**
  > An aircraft, after takeoff and close to maximum takeoff weight, stalled and crashed when the flaps were raised too soon, before sufficient acceleration.

  - Flaps were retracted at too low an airspeed.
  - Stalling speed increased due to flap retraction.
  - Aircraft stalled before reaching safe climb speed.
- **Considerations**
- Never retract flaps before accelerating to a safe airspeed.
- Monitor airspeed and keep wings level during climb.
- Be 100% concentrated on flight, especially after takeoff.
- **Special Circumstances**
- If engine fails during climb-out, how should it be addressed? Maintain control, lower nose to maintain airspeed, and prepare for emergency landing.

Stall in the Final Turn

> Stalling during the turn to final approach is one of the most dangerous phases of flight. The inside and outside wings have different angles of attack, and increasing bank angle can cause the wing to drop and the aircraft to stall.

- **Keypoints**
  - Occurs during the turn to final approach.
  - Right wing (in a left turn) travels at a higher angle of attack.
  - Increasing bank angle increases risk of stall.
  - Best solution if off centerline is to go around, not to increase bank.
- **Explanation**
  During the final turn, if the pilot tries to correct by increasing bank angle, the risk of stalling increases due to higher load factor and asymmetric lift. Keeping the ball centered and maintaining proper speed is crucial. If not aligned with the runway, a go-around is safer than risking a stall.
- **Examples**
  > A pilot, finding themselves right of the runway during the final turn, is advised not to increase bank angle to correct, but to go around instead.

  - Increasing bank angle increases load factor and stall speed.
  - Attempting to correct alignment by steepening the turn can cause a stall.
  - Going around is the safest option if not properly aligned.
- **Considerations**
- Keep the ball centered and maintain proper speed during final turn.
- Do not risk increasing bank angle to correct alignment; go around if necessary.
- **Special Circumstances**
- If off centerline during final turn, how should it be addressed? Execute a go-around rather than increasing bank angle.

Stalling Airspeed and Load Factor Relationship

> The stalling speed of an aircraft increases with the square root of the load factor. The formula for new stall speed is: V_s_new = V_s_old × sqrt(load factor).

- **Keypoints**
  - Stall speed increases as load factor increases.
  - Formula: V_s_new = V_s_old × sqrt(load factor).
  - Load factor can be calculated as 1 / cos(bank angle).
- **Explanation**
  When an aircraft is subjected to a higher load factor, such as during a banked turn,

the stall speed increases. For example, at a 60-degree bank, the load factor is 2, so the stall speed increases by a factor of sqrt(2) ≈ 1.41.

- **Examples**

  > If an aircraft normally stalls at 60 knots, at a 60-degree bank (load factor 2), the new stall speed is 60 × 1.41 = 85 knots.

  - Calculate load factor: 1 / cos(60°) = 2.
  - Calculate new stall speed: 60 × sqrt(2) = 85 knots.

  > If an aircraft stalls at 30 knots at 1G, with a 4G load factor, the new stall speed is 30 × 2 = 60 knots.

  - Load factor is 4G.
  - New stall speed: 30 × sqrt(4) = 30 × 2 = 60 knots.
- **Considerations**
- Always use the correct formula for stall speed under increased load factor.
- Remember that stall speeds provided in POH are for clean wings and 1G.
- **Special Circumstances**
- If bank angle is not standard, how should it be addressed? Calculate load factor using 1 / cos(bank angle) and apply the stall speed formula.

Effect of Wing Contamination on Stall Speed

> Wing contamination, such as ice or dirt, increases the stalling airspeed. All published stall speeds (e.g., in the POH) assume a clean wing.

- **Keypoints**
  - Contaminated wings increase stall speed.
  - All speeds in POH are for clean wings.
  - Always ensure wings are clean before flight.
- **Explanation**
  Contaminants on the wing disrupt airflow, reducing lift and increasing the speed at which the wing will stall. This is not reflected in the standard stall speeds provided in manuals.
- **Considerations**
- Check for wing contamination before flight.
- Do not rely solely on published stall speeds if wings are contaminated.
- **Special Circumstances**
- If wing contamination is detected, how should it be addressed? Remove contamination before flight and recalculate performance as necessary.

Indicated Stall Speed vs. True Airspeed

> Indicated stall speed is the speed shown on the airspeed indicator at which the aircraft will stall, regardless of altitude or density. True airspeed at which stall occurs increases with altitude, but indicated airspeed remains the same.

- **Keypoints**
  - Indicated stall speed does not change with altitude.
  - True airspeed at stall increases with altitude.
  - POH stall speeds are given as indicated airspeeds.
- **Explanation**
  At higher altitudes, air density decreases, so the true airspeed at which the aircraft stalls is higher, but the indicated airspeed remains the same. This can be confusing if not understood.
- **Examples**
  > If the indicated stall speed is 48 knots, the aircraft will stall at 48 knots indicated, regardless of being at 4,000 feet.

  - Indicated airspeed is used for stall reference.
  - Altitude does not affect indicated stall speed.
- **Considerations**
- Do not be confused by altitude when referencing indicated stall speed.

Load Factor Calculation Using Bank Angle

> Load factor in a banked turn is calculated as 1 divided by the cosine of the bank angle. This value is used to determine the increased stall speed during turns.

- **Keypoints**
  - Formula: Load factor = 1 / cos(bank angle).
  - At 60° bank, load factor is 2.
  - Higher bank angles result in higher load factors and stall speeds.
- **Explanation**
  For example, at a 60-degree bank, cos(60°) = 0.5, so load factor = 1 / 0.5 = 2. This load factor is then used in the stall speed formula.
- **Considerations**
- Always calculate load factor before determining stall speed in turns.

Battery Types and Characteristics

> Different types of batteries (e.g., lead-acid, nickel-cadmium) have different lifespans, electrolyte compositions, and behaviors under various conditions.

- **Keypoints**
  - Lead-acid batteries: 12 cells, affected by inoperative cells.

    - Nickel-cadmium batteries: electrolyte is not acid.
    - Battery capacity decreases with lower ambient temperature.
- **Explanation**
  Questions addressed include what happens if a cell in a lead-acid battery fails, how temperature affects battery capacity, and the composition of electrolytes in different battery types.
- **Considerations**
- Check battery health regularly.
- Be aware of temperature effects on battery performance.

Battery Capacity and Current Usage

> Understanding how to calculate the time a battery can supply a certain current based on its ampere-hour (Ah) rating.

- **Keypoints**
    - A 100Ah battery can be used by 25 amps for a specific time.
    - A battery rated at 20Ah can directly provide a current of 5A or 4A.
- **Examples**
  > Celia. A 100Ah battery can be used by 25 amps for a time of…

    - To find the time, divide the battery capacity by the current: 100Ah / 25A = 4 hours.

Parallel Connection of Batteries

> When two batteries are connected in parallel, the system voltage remains the same as one battery, but the capacity (Ah) is the sum of both.

- **Keypoints**
    - Two 12V 1400Ah batteries in parallel: voltage remains 12V, capacity becomes 2800Ah.
- **Examples**
  > Hugo. When two 12V 1400Ah batteries are connected in parallel, the total system voltage and capacity will be respectively…

    - Voltage remains 12V.
    - Capacity is 1400Ah + 1400Ah = 2800Ah.

Ammeter Readings and Alternator Function

> Ammeter readings indicate current flow direction and magnitude. If the needle is left of center and normalizes, the alternator is not providing the required electrical load.

- **Keypoints**
  - A 720 ammeter field with the needle left of center means the alternator is not able to provide the required electrical load.
  - When the alternator is supplying the busbar and charging the battery, the ammeter will be slightly to the right.
- **Examples**
  > Luke, your time. Your record has a 720 ammeter field. If the needle is left of a sinter and normalizes, what does this mean? The alternator is not able to provide the required electrical load.

  - Ammeter left of center: battery is discharging.
  - Ammeter right of center: battery is charging.

Battery Condition Check Using Voltmeter

> To check battery condition using the aircraft's voltmeter, a load should be applied to get a better indication of working conditions.

- **Keypoints**
  - Load should be applied during battery condition check.
  - If no current is supplied, the voltmeter will read zero.
- **Explanation**
  Whenever you have to check if the voltmeter is working properly, you need to supply it with current; otherwise, it would be on zero.

Aircraft Lead Acid Battery Ventilation

> Aircraft lead acid batteries are ventilated with fresh air to prevent the buildup of gases during charging.

- **Keypoints**
  - Ventilation is necessary during charging.

Nickel-Cadmium Battery Electrolyte

> The electrolyte of a nickel-cadmium battery is made of potassium hydroxide.

- **Keypoints**
  - Potassium hydroxide is the electrolyte.
- **Examples**
  > What is the electrolyte of a nickel-cadmium battery made of? Potassium hydroxide.

  - Potassium hydroxide is used as the electrolyte in nickel-cadmium batteries.

Advantages of Nickel-Cadmium Batteries

> Nickel-cadmium batteries have constant output voltage, low power loss at high temperature, greater internal resistance, reduced charging time, and greater energy density compared to lead-acid batteries.

- **Keypoints**
  - Constant output voltage
  - Low power loss at high temperature
  - Greater internal resistance
  - Reduced charging time
  - Greater energy density

Starter Circuit and Current Flow

> The starter circuit connects the battery to the starter motor, allowing a high current to flow through the starter switch in the start position.

- **Keypoints**
  - Current flow through the starter switch is high in the start position.

Load Factor Calculation in Aircraft Turns

> The load factor in a banked turn is calculated as 1 divided by the cosine of the bank angle. For a 60-degree turn, the load factor is 2g.

- **Keypoints**
  - Load factor = 1 / cos(bank angle)
  - Cosine of 60 degrees is 0.5, so load factor is 2g
- **Explanation**
  For a 60-degree bank, 1 / 0.5 = 2g.
- **Examples**
  > What is the value of the g load factor in the level 60 turn? One divided by cosine of your turn, which is 60 degrees. Cosine of 60 degrees is 0.5. So, one divided by two. Load factor is two G's.

  - Calculate cosine of 60 degrees: 0.5.
  - 1 / 0.5 = 2.
  - Load factor is 2g.

Maneuvering Speed (VA)

> VA is the maneuvering speed of the aircraft, a speed below which full, abrupt control movements can be made without overstressing the aircraft.

- **Keypoints**
  - VA is the maneuvering speed.

Ideal Fuel Mixture Ratio

> The ideal fuel mixture coefficient error in operation is 1 to 15, meaning 1 part fuel to 12 parts air.

- **Keypoints**
  - Ideal ratio: 1 part fuel to 12 parts air.
- **Examples**
  > You should do an ideal fuel mixture coefficient error in the operation 1 to 15, so 1 part fuel to 12 parts air.

  - The ideal mixture is 1:12 (fuel:air).

Aileron Movement During Pre-Flight Check

> When the pilot moves the control column to the left, the left aileron moves up and the right aileron moves down.

- **Keypoints**
  - Left aileron up, right aileron down when control column moved left.
- **Examples**
  > When conducting the pre-flight check, the pilot moves the control column to the left. The left aileron will move up, and the right aileron will move down.

  - Left movement: left aileron up, right aileron down.

Cooling Drag in Aircraft Engines

> Cooling drag refers to the additional drag caused by directing air over the engine for cooling purposes.

- **Keypoints**
  - Directing air on the engine results in a drag penalty called cooling drag.
- **Examples**
  > What does the term cooling drag mean? The need to direct air on the engine results in a drag penalty, sometimes called cooling drag.

  - Air inlets for cooling create additional drag.

Acceleration Measurement Unit

> The acceleration measurement unit innovation is expressed as 1.8 meters per second squared, relating to load factor g.

- **Keypoints**
  - 1.8 meters per second squared equals the acceleration regarding the aircraft pilots regarding load factor g.

Propeller Aerodynamics: Angle of Attack and Relative Airflow

> The angle of attack for a propeller blade is determined by the combination of the rotational airflow generated by the propeller and the airflow entering the propeller due to the aircraft's forward motion. The relative airflow is the vector sum of these two components. As aircraft speed increases, the horizontal component of the airflow vector increases, causing the angle of attack to decrease.

- **Keypoints**
  - Propeller blades are twisted to maintain a constant angle of attack along their length.
  - Relative airflow is the sum of the rotational airflow and the forward airflow.
  - At low speed (e.g., takeoff), the relative airflow is mostly due to rotation.
  - At high speed, the forward component dominates, reducing the angle of attack.
  - The angle of attack affects thrust and efficiency.
- **Explanation**
  The instructor explains that when the aircraft is stationary, the propeller's rotation creates airflow that is primarily rotational. As the aircraft moves forward, the airflow entering the propeller increases, changing the direction and magnitude of the relative airflow vector. This change affects the angle of attack, which in turn influences the thrust produced by the propeller. The blade twist is designed to keep the angle of attack relatively constant along the blade's length, compensating for the varying speeds at different points on the blade.
- **Examples**
  > When the aircraft is stationary, the propeller's rotation pushes air behind it, and the relative airflow is mainly from the rotation. When the aircraft is moving, the forward speed adds a horizontal component to the airflow, changing the angle of attack and the direction of the relative airflow vector.

  - Consider a stationary aircraft: the propeller rotates, pushing air backward.
  - The airflow experienced by the propeller is mainly due to its own rotation.
  - As the aircraft accelerates, the forward motion adds a horizontal airflow component.
  - The vector sum of rotational and forward airflow determines the relative airflow.
  - As forward speed increases, the angle of attack decreases.
- **Considerations**
- Always consider both rotational and forward airflow when analyzing propeller performance.

- Blade twist is essential for maintaining efficiency across the propeller.
- Changes in aircraft speed directly affect the angle of attack and thrust.
- **Special Circumstances**
- If encountering confusion about airflow vectors, break down the components into rotational and forward airflow and use vector addition to find the relative airflow.

Engine Break-in Procedures and Power Settings

> When a new engine is installed in an aircraft, there are specific recommendations for operating power settings during the initial hours of operation to ensure proper break-in and longevity. The recommended power settings and duration may vary, but generally, full power should be avoided for a specified period.

- **Keypoints**
  - After installing a new engine, operate at 65-75% power for the first 25 to 50 hours.
  - Full power or maximum power should only be used for up to 5 minutes, if at all.
  - Some recommendations extend the break-in period to 100 hours, avoiding full power.
  - Specific manifold pressure and RPM settings are advised during break-in.
- **Explanation**
  The instructor notes that while some sources suggest running a new engine at normal 65-75% power and using full power for 5 minutes, in practice, multi-engine aircraft procedures often require avoiding full power for up to 100 hours. Instead, pilots are instructed to use specific manifold pressure and RPM settings to ensure proper engine break-in.
- **Examples**
  > When a new engine is installed, pilots are told not to operate at full power for up to 100 hours, instead using specified manifold pressure and RPM settings.

  - Install a new engine.
  - For the first 100 hours, avoid full power settings.
  - Operate at recommended manifold pressure and RPM.
  - This helps ensure proper break-in and engine longevity.
- **Considerations**
- Follow manufacturer or instructor recommendations for break-in periods and power settings.
- Do not use full power unless specifically allowed and only for short durations.
- **Special Circumstances**
- If encountering conflicting recommendations, consult the aircraft’s operating manual or seek clarification from an instructor or maintenance professional.

Quiz and Examination Schedule and Procedures

> The lecture outlines the schedule for quizzes, main exams, and recovery exams, as well as the procedures for failing and retaking exams. There are specific days and times for each assessment, and students are given multiple opportunities to pass.

- **Keypoints**
  - POP exam is scheduled for Wednesday.
  - Recovery exams are scheduled for Friday, 23rd.
  - If a student fails the main exam, they have a second chance (recovery).
  - If the second chance is also failed, the coordinator (Diego) will discuss the reasons and may offer another opportunity.
  - Medical exams are scheduled for Tuesday at ten o’clock.
- **Explanation**
  The instructor explains that the main POP exam will be held on Wednesday, with recovery exams on Friday, 23rd. If a student fails the main exam, they have a second chance. If they fail again, the coordinator will intervene and may provide another opportunity. Medical exams are also scheduled and may conflict with other activities.
- **Examples**
  > A student who fails the main exam on Wednesday can take a recovery exam on Friday. If they fail again, the coordinator will discuss the reasons and possibly offer another chance.

  - Take the main POP exam on Wednesday.
  - If failed, take the recovery exam on Friday.
  - If failed again, meet with the coordinator for further discussion and possible additional opportunity.
- **Considerations**
- Be aware of exam dates and times.
- Plan for recovery exams if needed.
- Communicate with the coordinator if there are conflicts or issues.
- **Special Circumstances**
- If a medical exam conflicts with an assessment, notify the instructor or coordinator to resolve the scheduling issue.

Study Recommendations for Propeller Theory (Proverbs)

> The instructor provides guidance on how to study propeller theory, emphasizing the importance of understanding blade twist, torque, and the use of reference materials such as books, videos, and quizzes.

- **Keypoints**
    - Focus on understanding blade twist and its purpose (maintaining constant angle of attack).
    - Learn about torque and reaction forces in propeller systems.
    - Use books, videos, and quizzes for study.
    - If something is unclear, revisit the materials or ask for clarification.
- **Explanation**
  Students are advised to study the main points of propeller theory, especially blade twist and torque. The instructor suggests using a variety of resources and emphasizes the importance of understanding rather than rote memorization.
- **Examples**
  > If a student does not understand a concept, they should consult the book, watch videos, and do quizzes until the concept is clear.

    - Identify unclear topics.
    - Consult the textbook for detailed explanations.
    - Watch instructional videos for visual understanding.
    - Complete quizzes to test comprehension.
- **Considerations**
- Do not rely solely on one resource.
- Actively seek clarification for difficult concepts.
- **Special Circumstances**
- If a student continues to struggle with a concept after using all resources, they should ask the instructor for additional help.

Assignments & Suggestions

- Try doing the progress test again from my side, because the questions are always changing.
- Do the quiz on propeller theory.
- Read through notes and slides during the 10-minute break.
- Prepare for the POP exam on Wednesday.
- Prepare for recovery exams on Friday, 23rd.
- Use books, videos, and quizzes to study propeller theory.