2025-05-07 - AGK Lecture 2

> Date & Time: 2025-05-07 15:26:59
> Location: [Insert Location]
> [Insert Title]
> `Aircraft Systems` `Landing Gear` `Piston Engines`

Theme

This lecture provides an in-depth overview of aircraft systems, focusing on landing gear types, brake systems, shock absorption, and pre-flight inspections. It also covers the fundamentals of reciprocating piston engines, including the four-stroke cycle, ignition, fuel systems, and engine cooling. Practical procedures, safety checks, and troubleshooting tips are emphasized, with assignments and quizzes reinforcing key concepts for student pilots.

Takeaways

1. Residency appointment and immigration folders
2. Class attendance and missing students
3. Quiz completion at the end of each topic
4. Class schedule and early finish at 8
5. Trim tab and elevator operation
6. Videos on jet airplane and Cessna construction
7. Today’s topics: landing gear, wheels, brakes, tires, aero engines, fuel system, induction system
8. Progress test to be done at home every month
9. Types of landing gear: nose wheel (tricycle), tail wheel
10. Brake system: hydraulic system, pistons, brake pads

Highlights

- `"The instructors are here to help you."`
- `"Because learning from the books on how to fly, in my opinion, is impossible. So, to fly the aircraft, you should really fly by yourself and not me."`

- `"The whole process can be colloquially summed up in a phrase like suck, then squeeze, then bang, and then blow."`
- `"If the mixture explodes in a cylinder instead of burning, the result is detonation. This will cause serious damage to the engine very quickly and must be avoided at all costs."`
- `"So, you see, everything is automatically done by the engine, you just have to fly the aircraft."`
- `"I want you to be independent pilots, independent teachers, independent learners."`

Chapters & Topics

Residency Appointment and Immigration Folders

> Discussion about students' appointments for residency and the need for immigration folders. Specific names mentioned include Adrian, Anton, and Mohamed Dibad Aboud.

- **Keypoints**
  - Students must confirm their residency appointments.
  - Folders are required for immigration purposes.
  - Names must be checked and confirmed for folder collection.
- **Considerations**
- Ensure all students have their immigration folders.
- Verify names and appointments to avoid missing documentation.
- **Special Circumstances**
- If a student is missing or not present, check with classmates or have them return later.

Quiz Completion at the End of Each Topic

> Students are expected to complete quizzes at the end of each topic. There was confusion about the availability of quizzes in the exam section.

- **Keypoints**
  - Quizzes should be completed at the end of each topic.
  - Some students reported not seeing the quiz option.
  - Instructor insists quizzes are available and mandatory.
- **Considerations**
- Check the platform for quiz availability after each topic.
- Report technical issues to the instructor immediately.

- **Special Circumstances**
- If a quiz is not visible in the exam section, inform the instructor for troubleshooting.

Class Schedule and Early Finish

> The class will finish early at 8 due to the instructor's need to go to the airport for a simulator session.

- **Keypoints**
  - Class will end at 8.
  - Students are expected to study the day's topics at home.
- **Considerations**
- Plan to complete all in-class activities before 8.
- Use the extra time after class for self-study.
- **Special Circumstances**
- If class ends early, ensure all assignments and topics are covered or assigned for home study.

Trim Tab and Elevator Operation

> Explanation of how the trim tab and elevator work together to control the aircraft's nose position.

- **Keypoints**
  - Trimming the nose up: elevator goes up, trim tab goes down.
  - Trimming the nose down: trim tab goes up.
  - The trim tab and elevator are interconnected.
- **Explanation**
  When the pilot trims the nose up, the elevator moves up, and the trim tab moves down. The airflow pushes the trim tab, which in turn pushes the elevator up, raising the nose. The opposite occurs when trimming the nose down.
- **Considerations**
- Understand the relationship between trim tab and elevator movement.
- **Special Circumstances**
- If unsure about trim tab operation, review the video materials provided.

Types of Landing Gear

> Different configurations of landing gear, including nose wheel (tricycle) and tail wheel, and their operational differences.

- **Keypoints**
  - Nose wheel (tricycle) configuration: one nose wheel, two main landing gears.

    - Tail wheel configuration: wheel at the back of the aircraft.
    - Pilots require additional training to switch from nose wheel to tail wheel configuration.
- **Examples**
  > The Mooney Bravo aircraft uses a standard tricycle configuration with a nose wheel and two main landing gears.

    - The nose wheel supports the front of the aircraft.
    - Two main landing gears support the rear.
    - This configuration is common and requires standard pilot training.
- **Considerations**
- Pilots must be aware of the configuration they are flying.
- Additional training is needed for tail wheel aircraft.
- **Special Circumstances**
- If transitioning to a tail wheel aircraft, complete the required revalidation and training.

Brake System: Hydraulic System, Pistons, Brake Pads

> Aircraft brake systems use hydraulic mechanisms similar to cars, involving pistons, brake fluid, and brake pads.

- **Keypoints**
    - Brake system uses hydraulic fluid, which is incompressible.
    - Pressing the pedal moves a piston, which transmits force via fluid to another piston.
    - The second piston moves brake pads to stop the wheel.
- **Explanation**
  When the pilot presses the brake pedal, a piston compresses hydraulic fluid, which transfers the force to another piston connected to the brake pads. The brake pads then press against the wheel, slowing or stopping the aircraft.
- **Examples**
  > Pressing the brake pedal moves a piston, which pushes hydraulic fluid to another piston at the wheel, moving the brake pads to stop the wheel.

    - Pedal press = piston movement.
    - Hydraulic fluid transmits force.
    - Brake pads engage the wheel.
- **Considerations**
- Ensure hydraulic fluid levels are adequate.
- Check for leaks in the hydraulic system.
- **Special Circumstances**

- If brakes feel weak or unresponsive, inspect the hydraulic system for leaks or air bubbles.

Undercarriage: Definition and Types

> The undercarriage refers to the entire system of wheels, brakes, and related components. There are fixed and retractable types.

- **Keypoints**
  - Undercarriage includes wheels, brakes, and related systems.
  - Fixed undercarriage: always down, cannot be retracted.
  - Retractable undercarriage: can be raised or lowered via a cockpit lever.
- **Examples**
  > Cruiser aircraft have a fixed undercarriage, meaning the landing gear is always down and cannot be retracted.

  - No lever in cockpit for gear retraction.
  - Simplifies operation and maintenance.
- **Considerations**
- Know the type of undercarriage before flight.
- Operate the retraction lever only when safe and appropriate.
- **Special Circumstances**
- If the undercarriage fails to retract or extend, follow emergency procedures as per the aircraft manual.

Hydraulic System Mechanics: Input Force, Input Distance, Output Force, Output Distance

> Hydraulic systems use the principle that input force multiplied by input distance equals output force multiplied by output distance.

- **Keypoints**
  - Small input force over a large distance can move a large piston a small distance with considerable force.
  - Formula: Input Force x Input Distance = Output Force x Output Distance.
- **Explanation**
  This principle allows pilots to use minimal effort to achieve significant mechanical advantage in moving aircraft components such as landing gear and brakes.
- **Considerations**
- Understand the mechanical advantage provided by hydraulic systems.

Components of a Hydraulic System

> A hydraulic system consists of several key components: reservoir, pump, accumulator, selector valve, actuator, and non-return valve (NRB). Each component has a specific function in storing, pressurizing, directing, and utilizing hydraulic fluid to perform mechanical work.

- **Keypoints**
  - Reservoir: Stores all the hydraulic fluid, which is then distributed by pipes.
  - Pump: Pressurizes the fluid and moves it around the system.
  - Non-return valve (NRB): Ensures hydraulic fluid flows only in one direction.
  - Accumulator: A small reservoir that stores pressurized hydraulic fluid.
  - Selector valve: Controlled by the pilot to direct fluid flow.
  - Actuator: Converts hydraulic pressure into mechanical movement, e.g., for brakes or landing gear.
- **Explanation**
  The reservoir holds the hydraulic fluid. The pump pressurizes this fluid, which is then directed by the selector valve to the actuator. The NRB ensures one-way flow. The accumulator stores pressurized fluid for immediate use. The actuator performs the mechanical action, such as moving landing gear or brakes.
- **Examples**
  > When the pilot moves the selector valve, hydraulic fluid from the accumulator is directed to the actuator, which moves the landing gear up or down. The NRB ensures fluid only flows in the intended direction.

  - Pilot selects gear up or down using the selector valve.
  - Pump pressurizes fluid, which is stored in the accumulator.
  - Selector valve directs fluid to actuator.
  - Actuator moves landing gear accordingly.
  - NRB prevents backflow.
- **Considerations**
- Understand the function of each component for troubleshooting.
- Know the flow direction ensured by the NRB.
- **Special Circumstances**
- If the hydraulic system fails, landing gear may lower by gravity due to loss of hydraulic pressure.

Types of Hydraulic Systems: Passive and Active

> Hydraulic systems can be classified as passive (operated manually by the pilot) or active (operated automatically by a pump). The type used depends on the aircraft and the function required.

- **Keypoints**

    - Passive hydraulic system: Operated manually, e.g., by pressing pedals or moving levers.
    - Active hydraulic system: Operated automatically by a pump, requiring only pilot input to a lever or switch.
- **Explanation**
  In a passive system, the pilot directly operates the hydraulic mechanism, such as brakes or landing gear. In an active system, the pilot's input is limited to changing a lever's position, and the hydraulic system automatically performs the action.
- **Examples**
  > In the cruiser, there is only one hydraulic system, used for brakes. In multi-engine aircraft, the hydraulic system is used for both brakes and landing gear.

    - Single-engine: Passive system for brakes.
    - Multi-engine: Active system for landing gear and brakes.
- **Considerations**
- Identify which type of hydraulic system is present in the aircraft you are operating.

Hydraulic System Operation for Landing Gear

> The hydraulic system is primarily used to retract (raise) the landing gear. When lowering the gear, gravity does most of the work, with hydraulic pressure only needed to hold the gear up.

- **Keypoints**
    - Hydraulic pressure is required to keep landing gear up.
    - When lowering gear, gravity performs 90% of the work.
    - In most undercarriage systems, wheels are retracted and held by hydraulic force, and descend by gravity when released.
- **Explanation**
  When the pilot selects gear up, hydraulic pressure holds the gear in place. When gear down is selected, hydraulic pressure is released and gravity lowers the gear. If the hydraulic system fails, the gear will lower by gravity.
- **Examples**
  > If hydraulic pressure is lost, the undercarriage will lower under gravity, which is considered a safe failure mode.

    - Hydraulic failure releases pressure.
    - Gear descends by gravity.
    - No hydraulic power is needed for lowering.
- **Considerations**
- Understand the role of gravity in gear lowering.
- Be aware of the safe failure mode in hydraulic systems.

- **Special Circumstances**
- If encountering hydraulic failure, expect gear to lower by gravity and confirm gear position visually or by indicator.

Undercarriage Types and Functions

> Aircraft undercarriage can consist of wheels, floats, or skis, depending on the operating surface. The undercarriage system includes legs, wheels, tires, and a braking system, providing ground clearance and absorbing landing loads.

- **Keypoints**
  - Undercarriage types: wheels (conventional), floats (water), skis (snow/ice).
  - Undercarriage legs provide clearance for the propeller and aircraft body.
  - Acts as a spring to absorb landing forces.
- **Explanation**
  The undercarriage supports the aircraft on the ground, provides clearance, and absorbs shocks during landing. Different types are used for different surfaces.
- **Examples**
  > A Cessna equipped with floats operates on water surfaces.

  - Floats replace wheels for water landings.
  - Undercarriage system adapts to operating environment.
- **Considerations**
- Check undercarriage type before flight.
- Ensure adequate clearance and shock absorption.

Shock Absorption in Undercarriage: Spring Leaf and Oleo Systems

> Shock absorption in aircraft undercarriage is achieved using either spring leaf legs or oleo (oil-air) struts. Spring leaf is simple and cheap, while oleo is more sophisticated and provides smoother landings.

- **Keypoints**
  - Spring leaf undercarriage: Simple, elastic, acts like a spring, easy to maintain.
  - Oleo undercarriage: Uses piston and cylinder with oil and air, absorbs landing and taxiing loads, more complex and harder to maintain.
  - Combination systems exist, using both spring leaf and oil strut.
- **Explanation**
  Spring leaf systems bend to absorb energy, similar to car springs. Oleo systems compress air and force oil through a narrow opening, absorbing energy and providing smoother landings. Maintenance for oleo systems includes checking piston distance and system pressure.
- **Examples**

> Cruiser and Technum 2008 use spring leaf undercarriage; Piper uses oleo undercarriage.

  - Spring leaf: Simple, easy to check for cracks and fatigue.
  - Oleo: Requires checking oil/air pressure and piston distance.
- **Considerations**
- Check for cracks and fatigue in spring leaf systems.
- Check piston distance and pressure in oleo systems.
- Flight schools may prefer spring leaf for ease of maintenance.
- **Special Circumstances**
- If landing is hard, shock absorption system must be checked for damage.

Torque Links (Scissors) in Undercarriage

> Torque links, also called scissors, are mechanical linkages that prevent the wheel from rotating around the undercarriage leg, keeping the wheel assembly aligned.

- **Keypoints**
  - Torque links keep the cylinder and wheel assembly in place.
  - Prevents wheel from rotating around the leg axis.
  - Also called scissors.
- **Explanation**
  Without torque links, the wheel could rotate around the leg, causing misalignment and potential failure. Torque links ensure proper alignment during taxi, takeoff, and landing.
- **Examples**
  > A torque link connects the wheel assembly to the undercarriage leg, preventing unwanted rotation.

  - Torque link is installed between leg and wheel.
  - Prevents rotation and maintains alignment.
- **Considerations**
- Check torque links for wear and secure attachment.

Undercarriage Serviceability Checks and Tire Creep

> Pre-flight checks include inspecting the undercarriage for cracks, fatigue, and tire creep. Tire creep is monitored by aligning two red bars on the wheel and tire; misalignment indicates slippage.

- **Keypoints**
  - Check for cracks, fatigue, and metal condition.
  - Inspect tire and wheel for good condition.

    - Tire creep: Two red bars (one on wheel, one on tire) should be aligned.
    - Misalignment indicates tire slippage inside the wheel, reducing braking effectiveness.
- **Explanation**
  During walkaround, inspect the undercarriage for structural integrity. Check the alignment of tire creep marks; if misaligned, the tire may slip and reduce braking force.
- **Examples**
  > If the two red bars on the wheel and tire are not aligned, the tire is slipping inside the wheel, which can compromise braking.

    - Visual inspection of red bars.
    - Aligned: No slippage.
    - Misaligned: Tire creep present, report to mechanic.
- **Considerations**
- Do not fly if cracks or fatigue are found.
- Report tire creep to maintenance.
- **Special Circumstances**
- If tire creep is detected, do not rely on brakes and report immediately.

Landing Techniques to Avoid Undercarriage Damage

> Proper landing technique involves aligning the aircraft nose with the runway centerline to avoid side loads on the undercarriage, especially in crosswind conditions.

- **Keypoints**
    - Maintain nose alignment with runway centerline during landing.
    - Avoid side slip to prevent excessive stress on undercarriage.
    - Crosswind landings require special attention to alignment.
- **Explanation**
  Landing with the nose misaligned increases stress on the undercarriage, especially the gear that touches down first. Always aim for a straight, aligned touchdown.
- **Examples**
  > In crosswind, pilot aligns nose with centerline to avoid side loads and potential undercarriage breakage.

    - Use rudder to align nose.
    - Touch down with minimal side load.
- **Considerations**
- Practice alignment in simulator.

- Be aware of increased stress in crosswind landings.
- **Special Circumstances**
- If unable to align nose, consider going around to avoid undercarriage damage.

Types of Undercarriage and Maintenance

> Different aircraft use different types of undercarriage, such as oleo-type legs. The type and maintenance procedures are specified in the Pilot Operating Handbook (POH) or Flight Manual (FM), and pilot experience on type can provide guidelines for normal extension and maintenance.

- **Keypoints**
  - The undercarriage type and maintenance information are found in the POH or FM.
  - Oleo-type undercarriage legs show the amount of shiny piston to indicate proper air/oil fill.
  - Signs of leaking oil from seals or casing should be checked.
  - Torque links must be secure, and the nut and split pin holding the assembly together must be checked.
  - Shimmy damper security and condition should be checked if fitted.
- **Explanation**
  To determine the type of undercarriage and how to maintain it, refer to the POH or FM. For oleo-type legs, visually inspect the shiny piston extension to assess air/oil fill. Look for oil leaks, check torque link security, and inspect the shimmy damper if present.
- **Considerations**
- Always refer to the POH or FM for specific aircraft information.
- Visual inspection is crucial for detecting leaks or improper extension.
- **Special Circumstances**
- If you notice less shiny piston extension, fill more oil or air.
- If too much piston is exposed, depressurize the system slightly.

Brake Lining Minimum Thickness Requirements

> The brake lining or pad should be at least 0.1 inches (2.5 millimeters) thick. If the thickness is less than this, the brake pad must be changed before flight.

- **Keypoints**
  - Minimum brake lining thickness: 0.1 inches or 2.5 millimeters.
  - If thickness is less, the aircraft cannot be flown until the pad is replaced.
- **Explanation**
  Check the brake lining thickness during preflight inspection. If it is below 0.1 inches

(2.5 mm), maintenance is required before flight.

- **Considerations**
- Always measure brake lining thickness as part of preflight checks.
- **Special Circumstances**
- If brake lining is below minimum thickness, do not fly and arrange for replacement.

Differential Steering

> Differential steering is used in certain aircraft (e.g., Cruiser, Piper, Cessna, except P-2008) where the pedals control the brakes on each side, allowing the aircraft to turn by braking one wheel while the other is free.

- **Keypoints**
  - Pedals are not connected to the nose wheel; they operate the brakes.
  - To turn right, press the right pedal to lock the right brake; the left side remains free.
  - Over-braking can overheat and damage brake lines, especially plastic ones.
- **Explanation**
  When taxiing, use gentle, tapping pressure on the brakes to steer and avoid overheating. Do not push the pedals all the way down unless necessary.
- **Examples**
  > After a cross-country flight in 38 degrees summer heat, the brake fluid in plastic lines overheated, causing a loss of differential steering. The pilot had to steer onto grass and stop with a 360-degree turn.

  - High ambient temperature caused brake fluid to overheat.
  - Plastic brake lines melted, resulting in brake failure.
  - Pilot used alternative stopping method by steering onto grass.
- **Considerations**
- Avoid over-braking to prevent overheating and damage.
- Use tapping technique on brakes for better control and cooling.
- **Special Circumstances**
- If brakes fail due to overheating, steer to a safe area and stop using available means.

Nose Wheel Steering and Mechanical Linkage

> In aircraft with nose wheel steering (e.g., Piper, Cessna, Mupi engine Techno), the pedals are mechanically linked to the nose wheel, allowing direct steering. The wheel cannot be turned when stationary due to friction.

- **Keypoints**

    - Pedals are connected to nose wheel via mechanical linkage.
    - Steering is only possible while taxiing, not when stationary.
    - Forcing pedals while stationary can break the linkage.
- **Explanation**
  Only use pedal steering when the aircraft is moving. Do not attempt to turn the nose wheel while stationary.
- **Considerations**
- Do not force pedals when aircraft is not moving.
- **Special Circumstances**
- If mechanical linkage breaks, maintenance is required before further taxiing or flight.

Shimmy Damper and Nosewheel Shimmy

> Shimmy damper is a hydraulic piston assembly fitted to the nose wheel to dampen high-frequency oscillations (shimmy) that can occur during taxi, takeoff, or landing. Not all aircraft have shimmy dampers.

- **Keypoints**
    - Shimmy is a high-frequency oscillation of the nose wheel.
    - Shimmy damper absorbs these oscillations, preventing damage.
    - Cessna has a shimmy damper; Cruiser and Technum 2008 do not.
- **Explanation**
  If shimmy is felt during taxi or landing, check the shimmy damper's condition. If absent, be aware of potential vibrations.
- **Examples**
  > A video showed strong nose wheel oscillations during takeoff and landing on a C7272F. The shimmy was eradicated by replacing the nose wheel tower and rim, installing a new shim in the caesarean sling, and refactoring the scissor link.

    - Shimmy damper was ineffective, causing strong oscillations.
    - Maintenance actions resolved the issue.
- **Considerations**
- Check shimmy damper condition during preflight if fitted.
- **Special Circumstances**
- If strong shimmy occurs and damper is ineffective, maintenance is required.

Aircraft Tire Construction and Inflation

> Aircraft tires are designed to withstand high forces during landing and takeoff. Large jets use nitrogen for inflation, while smaller aircraft use normal air. Tire tread patterns are parallel to the direction of movement.

- **Keypoints**
  - Large jets use nitrogen; small aircraft use air.
  - Tread patterns are parallel longitudinal grooves.
  - Tire pressure is specified in the POH/FM.
- **Explanation**
  Check tire inflation and tread pattern before flight. Refer to POH/FM for correct pressure.
- **Considerations**
- Check tire pressure at ambient temperature.
- Inspect tread pattern for wear.
- **Special Circumstances**
- If tire pressure is incorrect, adjust according to POH/FM.

Tire Tread Pattern and Minimum Depth

> Aircraft tires must have a minimum tread depth of 2 millimeters over at least 75% of the tire area. If the tread is less than this, the aircraft cannot be flown.

- **Keypoints**
  - Minimum tread depth: 2 millimeters over 75% of tire area.
  - If below this, maintenance is required before flight.
- **Explanation**
  During preflight, inspect tire tread depth. If in doubt, consult a supervisor or instructor.
- **Examples**
  > Students who found flat tires or destroyed tread had their flights cancelled or delayed until the tire was changed.

  - Tire condition directly affects flight safety.
  - Supervisor or instructor can assist in decision-making.
- **Considerations**
- If unsure about tread depth, consult a supervisor.
- Send a picture to the instructor if in doubt.
- **Special Circumstances**
- If tread depth is less than 2 mm over 75% area, do not fly.

Tire Pressure Adjustment for Temperature Changes

> Tire pressure varies with temperature. If the aircraft is flown to a location with a temperature difference of plus or minus 25 degrees from the home airport, tire pressure may need to be adjusted.

- **Keypoints**
  - High temperatures require reduced tire pressure.
  - Low temperatures require increased tire pressure.
  - Pressure should be checked at ambient temperature.
- **Explanation**
  After landing, wait up to an hour for tires to cool before checking pressure. Adjust pressure if flying to locations with significant temperature differences.
- **Considerations**
- Check tire pressure only at ambient temperature.
- **Special Circumstances**
- If flying to a location with ±25 degrees temperature difference, adjust tire pressure accordingly.

Tire Inspection Criteria (Cuts, Bulges, Tread Depth)

> Tires must be inspected for cuts, bulges, and tread depth. Cuts should be less than 50% of tread depth and not cross more than 50% of 10 wings. Marked bulges in the sidewall indicate the tire is unfit for flight.

- **Keypoints**
  - Cuts: less than 50% of tread depth, not crossing more than 50% of 10 wings.
  - Marked bulges in sidewall: do not fly.
  - Consult instructor if unsure.
- **Explanation**
  During preflight, inspect for cuts and bulges. If a marked bulge or excessive cut is found, do not fly.
- **Considerations**
- Consult instructor if unsure about tire condition.
- **Special Circumstances**
- If a marked bulge is found, do not fly.
- If cuts exceed limits, do not fly.

Aquaplaning (Hydroplaning) and Its Formula

> Aquaplaning (hydroplaning) occurs when standing water, slush, or snow causes the aircraft wheel to lose contact with the surface, reducing or eliminating braking action. The dynamic hydroplaning spin-up speed can be calculated as the square root of the tire pressure.

- **Keypoints**
  - Aquaplaning reduces or eliminates braking action.
  - Formula: Spin-up speed = square root of tire pressure.

    - Example: For tire pressure 33.4 psi, spin-up speed is 52 knots.
- **Explanation**
  Use the formula to estimate the speed at which hydroplaning may occur. For most small aircraft, this is not a significant concern, but it is important for larger jets.
- **Examples**
  > If the POH SOCATA states tire pressure is 33.4 psi, the dynamic hydroplaning spin-up speed is 52 knots. At this speed, there is a high possibility of hydroplaning.

    - Calculate square root of 33.4 to get 5.78, then multiply by 9 to get 52 knots (implied calculation).
    - If aircraft speed is higher than 52 knots, the wheel will attach to the ground.
- **Considerations**
- Be aware of hydroplaning risk in wet, slushy, or snowy conditions.
- **Special Circumstances**
- If hydroplaning is suspected, reduce speed and avoid heavy braking.

Types of Aircraft Brakes (Drum vs Disc)

> Older aircraft used drum brakes, which are heavier and less effective than modern disc brakes. Drum brakes have brake pads inside the rim that expand to touch the rim and slow the wheel.

- **Keypoints**
    - Drum brakes are outdated and heavier.
    - Disc brakes are more effective and lighter.
- **Explanation**
  Understand the difference between drum and disc brakes for maintenance and operational awareness.
- **Examples**
  > A video demonstrated a drum brake system where pressing the brake pedal expands the drum, causing it to touch the wheel and slow it down.

    - Drum expands when brake is applied.
    - Contact with wheel rim slows rotation.

Drum Brake System

> The drum brake system consists of a metal ring attached to the wheel, which rotates with it. The braking pad (also called brake lining or brake pad, depending on construction and design) is pressed against the metal ring when the brake pedal is applied, causing the wheel to slow down or stop.

- **Keypoints**
  - Metal ring rotates with the wheel.
  - Brake pads/linings are pressed against the ring to create friction.
  - Over-braking can overheat the system.
  - Brake pads and brake linings are terms used based on construction and design.
- **Explanation**
  When the driver presses the brake pedal, the brake pads move to touch the metal ring, causing friction and slowing the wheel. Braking should be done gradually to avoid overheating.
- **Examples**
  > If the brake is pressed too hard, the system may overheat, causing the vehicle to lose braking efficiency and potentially go off the intended path (e.g., into the grass).

  - Pressing the brake pedal too hard increases friction and heat.
  - Overheating reduces braking effectiveness.
  - Gradual braking is recommended to prevent this.
- **Considerations**
- Do not brake very hard to avoid overheating.
- Understand the difference between brake pads and brake linings.

Passive Hydraulic Braking System

> A passive hydraulic braking system is operated manually by the pilot (or driver), as opposed to an active system which is operated automatically. The system uses hydraulic fluid to transfer force from the pedal to the brake pads.

- **Keypoints**
  - Operated manually by the pilot's feet.
  - Similar to car braking systems.
  - Hydraulic fluid moves pistons to apply brakes.
  - Aircraft may have more complex systems with multiple hydraulic circuits.
- **Explanation**
  When the brake pedal is pressed, a piston moves hydraulic fluid, which then moves another piston connected to the brake pads, causing them to press against the metal ring and slow the wheel.
- **Examples**
  > The passive hydraulic braking system in aircraft is fundamentally the same as in cars, with the pilot pressing the pedal to move hydraulic fluid and apply the brakes.

  - Pressing the pedal moves a piston.

    - Hydraulic fluid is displaced.
    - Another piston moves the brake pads.
- **Considerations**
- Aircraft systems may have three hydraulic systems, making them more complex.
- Focus on understanding the basic principle, which is the same as in cars.

Parking Brake Operation

> The parking brake is used to keep the aircraft stationary without the need to continuously press the brake pedals. The procedure involves pressing the pedals to pressurize the system and then engaging the parking brake switch or lever.

- **Keypoints**
    - Press pedals hard to pressurize the system.
    - Engage the parking brake switch/lever.
    - Acts like a cap to keep hydraulic pressure in the system.
    - Different aircraft have different parking brake designs.
- **Explanation**
  To engage the parking brake, first press the brake pedals to apply pressure, then activate the parking brake control. This locks the brakes in place until released.
- **Examples**
  > On the Piper, press the pedals and pull the parking brake lever. On the Cruiser, push the pedal and pull the switch to engage the parking brake.

    - Press pedals to apply brakes.
    - Pull the parking brake lever or switch.
    - Brakes remain engaged until released.
- **Considerations**
- Do not leave the parking brake engaged overnight; use chocks instead.
- Understand the specific procedure for each aircraft type.
- **Special Circumstances**
- If leaving the aircraft overnight, disengage the parking brake and use chocks to prevent movement.

Differential Braking

> Differential braking allows the pilot to apply brakes to one side of the aircraft, enabling tighter turns and improved directional control, especially during ground operations.

- **Keypoints**
    - Two brakes, one on each wheel.

    - Applying brake to one side causes the aircraft to turn in that direction.
    - Allows for very tight turning circles.
    - Easier directional control, especially in crosswind conditions.
- **Explanation**
  By pressing the right or left brake pedal, the corresponding wheel slows down or stops, causing the aircraft to pivot around that wheel. This is useful for maneuvering on the ground.
- **Examples**
  > Fully pressing the right pedal causes the aircraft to turn sharply to the right in a small circle.

    - Right brake applied, right wheel slows/stops.
    - Left wheel continues moving.
    - Aircraft pivots around right wheel.
- **Considerations**
- High power settings may be needed for very tight turns.
- Frequent sharp turns can be hard on landing gear.
- **Special Circumstances**
- If the nose or tail wheel is free to castor, the aircraft can turn in a very tight circle, but care must be taken not to lock one wheel completely, as this can damage the landing gear.

Toe Brakes

> Toe brakes are a type of pedal system where the upper part of the pedal is used for braking and the lower part for steering. Commonly found on Cessna and Piper aircraft.

- **Keypoints**
    - Two separate pedal areas: top for brakes, bottom for steering.
    - Press upper pedal to brake, lower pedal to steer.
    - Not used on all aircraft (e.g., not on Cruiser).
- **Explanation**
  Pilots must press the upper part of the pedal to engage the brakes. Pressing only the lower part will steer but not stop the aircraft.
- **Examples**
  > Pilots transitioning from Cruiser to Cessna or Piper may be confused by the different pedal sizes and functions.

    - Cessna and Piper have larger pedals with separate brake and steering areas.
    - Cruiser has smaller pedals.
- **Considerations**

- Familiarize yourself with the pedal layout before flying a new aircraft type.

Braking Techniques During Taxi and Landing

> Proper braking techniques are essential for safe taxiing and landing. Brakes should be checked at the start of taxi, and during landing, braking should only begin after all three wheels are on the ground.

- **Keypoints**
  - Check brakes at the start of taxi by pressing both pedals.
  - If brakes malfunction, stop and call mechanics.
  - During landing, do not brake until nose wheel is on the ground.
  - Braking too early can damage the nose wheel.
- **Explanation**
  After touchdown, let the aircraft roll until all wheels are on the ground before applying brakes gradually. This prevents slamming the nose wheel and potential damage.
- **Examples**
  > Students have damaged the nose wheel by braking before the nose wheel touched down.

  - Braking with nose in the air causes the nose to slam down.
  - Wait until all three wheels are on the ground before braking.
- **Considerations**
- Always check brakes before taxi.
- Do not rush to brake after landing.
- **Special Circumstances**
- If the runway is very long, you may not need to use brakes at all; let the aircraft roll to a stop.

Circumstances Where Brakes Are Not Used

> There are situations where brakes are not used to stop the aircraft, such as on very long or contaminated runways.

- **Keypoints**
  - On long runways, allow the aircraft to roll to a stop without braking.
  - On contaminated runways, avoid using brakes to prevent skidding.
- **Explanation**
  If landing far from the terminal or on a long runway, pilots may let the aircraft roll and vacate the runway without using brakes. On contaminated runways, braking may be unsafe.

- **Examples**
  > Landing on runway 22 at Burgos, pilots may not use brakes and let the aircraft roll to the taxiway.

  - Touch down at the marked bars.
  - Let the aircraft roll to the desired exit.
- **Considerations**
- Assess runway length and surface conditions before deciding to use brakes.
- **Special Circumstances**
- If the runway is contaminated, avoid using brakes to prevent loss of control.

SPATS (Aerodynamic Wheel Covers)

> SPATS are aerodynamic covers made of composite material placed over wheels to reduce drag. They are not used in all fleets due to maintenance and inspection concerns.

- **Keypoints**
  - Reduce aerodynamic drag.
  - Can collect mud and debris, affecting wheel rotation.
  - Make tire inspection difficult.
- **Explanation**
  SPATS improve aerodynamics but can cause operational issues on muddy surfaces and hinder tire checks.
- **Considerations**
- Not used in some fleets to allow easy tire inspection.

Towing Procedures

> Towing procedures vary depending on aircraft weight. Light aircraft like the Cruiser can be towed by hand, while multi-engine aircraft require a tow bar and assistance.

- **Keypoints**
  - Light aircraft (e.g., 300 kg Cruiser) can be pulled by hand after releasing parking brake.
  - Multi-engine aircraft require a tow bar and may need two people.
- **Explanation**
  Attach the tow bar to the wheel and pull the aircraft out of the hangar. For heavier aircraft, get assistance.
- **Examples**
  > The instructor and examiner had to work together to pull a heavy multi-engine aircraft out of the hangar.

    - Attach tow bar.
    - Both people pull together.
- **Considerations**
- Always release the parking brake before towing.
- Do not attempt to tow heavy aircraft alone.

Pre-flight Brake and Tire Inspection

> Pilots must check tire inflation, creep marks, bulging, cuts, and flat spots during pre-flight inspection to ensure safety.

- **Keypoints**
    - Check tire inflation.
    - Inspect creep marks.
    - Look for bulging, cuts, and flat spots.
    - Check for missing tread (flat spots).
- **Explanation**
  A thorough inspection helps identify potential issues before flight, reducing the risk of tire or brake failure.
- **Considerations**
- Do not fly if any tire or brake issue is found.

Quiz Content and Questions

> A quiz with 5 questions was conducted, covering topics such as creep marks, OLEO struts, under-inflated tires, and pre-flight inspection items.

- **Keypoints**
    - Quiz had 5 questions.
    - Topics included alignment of wheel ring, OLEO shock absorber, oil damping, under-inflated tire risks, and pre-flight inspection.
- **Explanation**
  Students answered questions together and discussed correct answers.

Reciprocating Piston Engines

> Aircraft in the PPL course use reciprocating piston engines, similar to those in cars. Jet engines are covered in phase two.

- **Keypoints**
    - Reciprocating piston engine is the standard for PPL aircraft.
    - Same basic operation as car engines.
    - Jet engines are taught in later phases.

- **Explanation**
  The reciprocating piston engine uses pistons to convert fuel into mechanical energy, powering the aircraft.
- **Considerations**
- Focus on piston engines for PPL; jet engines will be covered later.

Principle of Piston Engine Operation

> The piston engine operates by moving a piston up and down inside a cylinder. The movement is driven by the intake of an air-fuel mixture, compression, ignition (explosion), and exhaust. The up and down motion of the piston is converted into rotary motion by the crankshaft, which can then drive a propeller or a gearbox.

- **Keypoints**
  - Piston moves up and down inside a cylinder.
  - Air-fuel mixture enters the cylinder through a valve.
  - Mixture is compressed as piston moves up.
  - Igniter (spark plug) ignites the compressed mixture, causing an explosion.
  - Explosion forces piston down, opening exhaust valve.
  - Exhaust gases exit through exhaust pipe.
  - Crankshaft converts linear piston motion to rotary motion.
  - Cycle repeats continuously.
- **Explanation**
  The instructor explains that the main part of the engine is the piston, which moves up and down inside the cylinder. When the piston goes down, the intake valve opens and the air-fuel mixture enters. As the piston moves up, it compresses the mixture. At the correct timing, the igniter provides a spark, causing an explosion that pushes the piston down. The exhaust valve then opens to release the burnt gases. The crankshaft, connected to the piston, rotates as a result of this motion, providing power to the propeller or gearbox.
- **Considerations**
- Correct timing of ignition is crucial for efficient operation.
- Proper sealing of valves is necessary to maintain compression.
- **Special Circumstances**
- If the ignition timing is off, the engine may misfire or lose power.
- If the exhaust valve fails to open, exhaust gases will not be expelled, causing engine malfunction.

Four-Stroke (Otto) Cycle

> The Otto cycle consists of four strokes: induction (intake), compression, expansion (power), and exhaust. This cycle is fundamental to the operation of piston engines in cars and airplanes.

- **Keypoints**
  - Induction: Air-fuel mixture enters the cylinder.
  - Compression: Piston moves up, compressing the mixture.
  - Ignition: Spark ignites the mixture (not always counted as a separate stroke).
  - Expansion (Power Stroke): Explosion pushes piston down.
  - Exhaust: Burnt gases are expelled from the cylinder.
- **Explanation**
  The instructor details each phase of the Otto cycle, emphasizing the cyclical nature of the process. The expansion phase is also called the power stroke, as it is when the explosion occurs and power is generated. The cycle can be remembered as 'suck, squeeze, bang, blow.'
- **Considerations**
- Each stroke must occur in the correct sequence for the engine to function.
- Proper mixture and timing are essential for efficient combustion.
- **Special Circumstances**
- If the mixture is too rich or too lean, combustion may be incomplete, reducing power and increasing emissions.

Crankshaft Function and Connection

> The crankshaft is connected to the piston and converts the piston's up and down (reciprocating) motion into rotary motion, which is necessary to drive the propeller or gearbox.

- **Keypoints**
  - Crankshaft rotates as piston moves up and down.
  - Provides rotary motion for propeller or gearbox.
  - Continuous rotation as long as engine runs.
- **Explanation**
  The instructor describes the crankshaft as an essential component that is always rotating when the engine is running. It is connected to the piston and is responsible for converting the linear motion into rotary motion.
- **Considerations**
- Crankshaft must be robust to withstand repeated explosions and forces.
- Proper lubrication is necessary to prevent wear.
- **Special Circumstances**
- If the crankshaft fails, the engine will stop functioning immediately.

Compression Ratio

> Compression ratio is the ratio of the total cylinder volume (when the piston is at Bottom Dead Center) to the clearance volume (when the piston is at Top Dead Center). It affects engine power and efficiency.

- **Keypoints**
  - Total cylinder volume: Volume when piston is at BDC.
  - Clearance volume: Volume when piston is at TDC.
  - Compression ratio = Total cylinder volume / Clearance volume.
  - Higher compression ratio can mean more power, but also more stress on engine components.
- **Explanation**
  The instructor explains how the piston moves between BDC and TDC, creating different volumes. The compression ratio is a key parameter in engine design and performance.
- **Considerations**
- Higher compression ratios require higher octane fuel to prevent knocking.
- Engine design must account for increased pressures.
- **Special Circumstances**
- If the clearance volume is too small, risk of engine knocking increases.

Brake Horsepower (BHP) and Torque

> Brake horsepower is the measure of the power developed by an engine at a stated RPM, measured at the crankshaft. Torque is the measure of the strength of the rotational movement of the engine.

- **Keypoints**
  - BHP is measured at the crankshaft.
  - Higher RPM generally means higher power.
  - Torque is the rotational force produced by the engine.
  - Power is the rate at which torque is produced.
- **Explanation**
  The instructor provides examples: Lycoming engine in Sokata TB10 provides 180 BHP at 2,700 RPM; Rotax 912 engine provides 100 HP. Torque is important for turning the propeller, especially with wider blades. Higher torque results in better take-off, climb, and lower fuel consumption at cruise.
- **Examples**
  > In a Sokata TB10, there’s a Lycoming engine, which provides 180 brake horsepower at 2,700 RPM.

    - The Lycoming engine is used as an example to illustrate how brake horsepower is specified at a particular RPM.
    - This helps pilots understand the relationship between engine speed and power output.

  > In a cruiser, there is a Rotax 912 engine, which provides 100 horsepower.

    - The Rotax 912 is described as underpowered, but still functional for flight.
    - This example shows the variation in engine power across different aircraft.
- **Considerations**
- Pilots monitor RPM and power settings during flight.
- Higher torque allows for wider propeller blades and more thrust.
- **Special Circumstances**
- If torque is insufficient, the aircraft may have poor take-off and climb performance.

Cylinder Head Temperature (CHT) Monitoring

> Cylinder head temperature is monitored using a thermometer attached to the cylinder head. High temperatures can indicate engine problems and risk of damage.

- **Keypoints**
    - CHT is measured directly on the cylinder head.
    - High CHT can melt engine components.
    - Pilots can adjust power to manage temperature.
    - Maximum allowable CHT is specified in the POH/FM.
- **Explanation**
  The instructor emphasizes the importance of monitoring CHT to prevent engine damage. Procedures for high temperature situations are taught in the SOP course.
- **Considerations**
- Always refer to the POH/FM for maximum allowable CHT.
- Adjust power settings if CHT is too high.
- **Special Circumstances**
- If CHT exceeds limits, reduce power and follow emergency procedures as taught in SOP course.

Induction System and Carburetor

> The induction system brings air from outside the aircraft, mixes it with fuel in the carburetor, and delivers the mixture to the cylinder. The system includes air intake, filter, carburetor, and intake lines.

- **Keypoints**
    - Air enters through a filter to prevent debris.

    - Fuel is mixed with air in the carburetor.
    - Mixture is delivered to the intake valve and cylinder.
    - Throttle controls the amount of mixture entering the engine.
    - Mixture control (in some aircraft) adjusts fuel-to-air ratio.
- **Explanation**
  The instructor explains that the pilot uses the throttle to control engine power and, in some aircraft, a mixture control to adjust the fuel-to-air ratio, especially at different altitudes.
- **Considerations**
- Ensure air filter is clean to prevent engine damage.
- Adjust mixture control according to altitude (if available).
- **Special Circumstances**
- If debris enters the induction system, engine performance may be compromised.

Ignition System and Magnetos

> The ignition system provides the spark needed to ignite the air-fuel mixture. Magnetos generate high-voltage electricity for the spark plugs. Dual magnetos are used for safety.

- **Keypoints**
    - Magnetos generate high-voltage current for spark plugs.
    - Each magneto connects to specific spark plugs.
    - Dual magnetos ensure redundancy; if one fails, the other continues to operate.
    - High-tension leads carry current to spark plugs.
- **Explanation**
  The instructor describes the wiring of magnetos to spark plugs and the importance of redundancy for safety. Pilots check magneto function during pre-flight checks.
- **Considerations**
- Always check both magnetos during pre-flight.
- Understand which spark plugs are connected to each magneto.
- **Special Circumstances**
- If one magneto fails in flight, continue operating on the remaining magneto and land as soon as practical.

Magneto Ignition System Operation and Testing

> The magneto ignition system in aircraft engines provides sparks to the spark plugs. The ignition switch has positions: off, right, left, both, and start. Testing involves switching between left, right, and both positions to observe RPM changes, ensuring both magnetos are functioning.

- **Keypoints**
  - Insert key and turn to start to engage engine.
  - Both position: both magnetos and spark plugs are working.
  - Left or right position: only one magneto is working, causing a slight RPM drop.
  - Switching directly from left to right is not a problem.
  - RPM increases when both magnetos are engaged.
- **Explanation**
  When starting, the key is turned to start, then released. To test magnetos, switch from both to left: RPM drops as only one magneto fires all four cylinders. Return to both: RPM rises. Switch to right: RPM drops again. Return to both: RPM rises. This checks both magnetos independently.
- **Examples**
  > During pre-flight checks, the pilot switches the ignition from both to left, observes a small RPM drop, returns to both, then switches to right, observes another RPM drop, and returns to both. This confirms both magnetos are operational.

  - Insert key and start engine.
  - Switch to left magneto: observe RPM drop.
  - Switch back to both: RPM increases.
  - Switch to right magneto: observe RPM drop.
  - Switch back to both: RPM increases.
- **Considerations**
- Always check for RPM drop when switching magnetos.
- Do not ignore significant RPM drops or rough running.
- **Special Circumstances**
- If encountering a situation where there is no RPM drop or the engine runs rough on one magneto, the magneto may be faulty and should be inspected before flight.

Detonation in Engines

> Detonation occurs when the fuel-air mixture explodes in the cylinder instead of burning in a controlled way. This can cause severe engine damage quickly and must be avoided.

- **Keypoints**
  - Controlled burning of fuel-air mixture is essential.
  - Premature explosion leads to detonation.
  - Detonation can damage the engine rapidly.
  - If detonation occurs, turn off the engine immediately.

- **Explanation**
  If the mixture explodes before the correct timing, the resulting detonation can damage engine components. The only remedy is to shut down the engine to prevent further damage.
- **Examples**
  > A pilot notices knocking sounds and loss of power, indicating detonation. The pilot immediately shuts down the engine to prevent catastrophic failure.

  - Pilot detects abnormal engine noise.
  - Recognizes symptoms of detonation.
  - Shuts down engine to avoid further damage.
- **Considerations**
- Monitor for signs of detonation during operation.
- Do not continue running the engine if detonation is suspected.
- **Special Circumstances**
- If encountering detonation, how should it be addressed? Turn off the engine immediately and do not attempt to restart until inspected.

Mechanical Components: Piston, Crankshaft, Connecting Rod

> The piston converts reciprocating motion to rotational motion via the crankshaft, connected by a connecting rod (conrod). The small end connects to the piston, the big end to the crankshaft.

- **Keypoints**
  - Piston moves up and down, connected to crankshaft by conrod.
  - Small end: bearing between conrod and piston.
  - Big end: bearing between conrod and crankshaft.
  - Crankshaft drives the propeller.
- **Explanation**
  The piston's up-and-down motion is transferred to the crankshaft through the connecting rod. The crankshaft's rotation spins the propeller.
- **Examples**
  > In a typical aircraft engine, the piston's movement is transferred to the crankshaft via the connecting rod, which then rotates the propeller.

  - Piston moves due to combustion.
  - Connecting rod transmits force to crankshaft.
  - Crankshaft rotates, spinning the propeller.
- **Considerations**
- Understand the terminology: small end, big end, conrod.

Valve Operation: Camshaft and Crankshaft Relationship

> The opening of intake and exhaust valves is controlled by a rotating camshaft, which is connected to the crankshaft but runs at half the engine speed, as valves only need to open once every two crankshaft rotations.

- **Keypoints**
  - Camshaft controls valve timing.
  - Camshaft runs at half the speed of the crankshaft.
  - Ensures correct valve operation in the Otto cycle.
- **Explanation**
  The camshaft is geared to the crankshaft so that it rotates at half speed, opening and closing valves at the correct times during the engine cycle.
- **Examples**
  > In a four-stroke engine, the camshaft opens the intake and exhaust valves at precise intervals, synchronized with the crankshaft's rotation.

  - Crankshaft rotates twice for each camshaft rotation.
  - Camshaft lobes push valves open at correct times.
- **Considerations**
- Remember the speed relationship between camshaft and crankshaft.

Cooling and Lubrication Systems

> Aircraft engines are cooled by air or liquid, similar to cars. Lubrication is provided by oil. Poor engine management may result in short cooling, which is discussed in more detail elsewhere.

- **Keypoints**
  - Air-cooled and liquid-cooled systems exist.
  - Oil is used for lubrication.
  - Short cooling can damage the engine.
- **Explanation**
  Air or liquid removes heat from the engine. Oil lubricates moving parts. Short cooling refers to rapid cooling, which can cause damage.
- **Examples**
  > A light aircraft uses air passing over baffles to cool the engine cylinders.

  - Air enters engine compartment.
  - Baffles direct air over hot surfaces.
  - Heat is carried away by airflow.
- **Considerations**
- Monitor engine temperature to avoid short cooling.

- **Special Circumstances**
- If encountering rapid engine cooling (short cooling), how should it be addressed? Avoid abrupt power reductions and allow gradual cooling.

Cylinder Arrangements in Engines

> Engines may have cylinders arranged vertically, horizontally opposed, in a rotary, radial, V-shape, or W-shape configuration. Each arrangement has specific characteristics and historical usage.

- **Keypoints**
  - Vertical cylinders: common in cars.
  - Horizontally opposed: common in aircraft, saves space.
  - Rotary: entire engine rotates, obsolete.
  - Radial: cylinders arranged around crankshaft, engine fixed.
  - V-shape and W-shape: used in historical engines.
- **Explanation**
  Different arrangements affect engine size, cooling, and maintenance. Horizontally opposed engines are preferred in aircraft for compactness.
- **Examples**
  > A four-cylinder horizontally opposed engine is used in a training aircraft, with two cylinders on each side.

  - Cylinders are arranged horizontally.
  - Engine fits neatly in aircraft nose.
- **Considerations**
- Recognize the advantages of horizontally opposed engines in aircraft.

Two-Stroke Engine Operation and Characteristics

> Two-stroke engines complete a power cycle in two strokes, making them lighter and simpler than four-stroke engines. They require oil to be mixed with fuel for lubrication, and are prone to spark plug fouling.

- **Keypoints**
  - Fuel-air mixture drawn into crankcase as piston moves up.
  - Mixture compressed and transferred to cylinder.
  - Power and exhaust strokes occur every other stroke.
  - Oil must be mixed with fuel.
  - Spark plug fouling is common.
- **Explanation**
  As the piston moves, it alternately draws in and compresses the mixture, with power

delivered every other stroke. Oil in the fuel lubricates the engine but can foul spark plugs.

- **Examples**
  > A motorcycle engine requires the rider to mix oil with fuel at each refueling to ensure proper lubrication.

  - Rider calculates oil-to-fuel ratio.
  - Mixes oil and fuel before filling tank.
- **Considerations**
- Always mix oil and fuel in correct proportions.
- Check for spark plug fouling regularly.
- **Special Circumstances**
- If encountering excessive spark plug fouling, how should it be addressed? Clean or replace spark plugs and check oil mixture ratio.

Supercharger in Two-Stroke Engines

> A supercharger can be used in two-stroke engines to compress the fuel-air mixture before it enters the cylinder, eliminating the need to mix oil with fuel.

- **Keypoints**
  - Supercharger compresses mixture before intake.
  - No need to mix oil with fuel.
  - Engine cooling issues remain.
- **Explanation**
  The supercharger handles mixture compression, so lubrication can be managed separately, simplifying operation.
- **Examples**
  > A two-stroke engine with a supercharger does not require pre-mixed oil and fuel, reducing maintenance complexity.

  - Supercharger compresses intake mixture.
  - Lubrication system is separate from fuel.
- **Considerations**
- Understand the difference in lubrication requirements with supercharged engines.

Rotary (Wankel) Engine Design and Operation

> The Wankel rotary engine uses a triangular rotor inside an oval chamber, with only three major components: casing, rotor, and central shaft. It completes the Otto cycle with intake, compression, power, and exhaust strokes.

- **Keypoints**

    - Rotor has quasi-triangular (epitrochoid) shape.
    - Three gas-tight chambers formed by rotor tips.
    - Four strokes: intake, compression, power, exhaust.
    - No pistons, crankshaft, camshaft, or valves.
- **Explanation**
  The rotor rotates within the chamber, sequentially performing the four strokes as its chambers pass the intake, ignition, and exhaust ports.
- **Examples**
  > Mazda used the Wankel rotary engine in some car models, utilizing the unique rotor design for smooth power delivery.

    - Rotor rotates inside chamber.
    - Each face of rotor performs a different stroke.
- **Considerations**
- Recognize the simplicity and compactness of the Wankel engine.

Hybrid and Electric Aircraft Engine Developments

> Hybrid and electric propulsion systems are being developed for aircraft, including fully electric prototypes and hybrid designs with both conventional and electric engines. Hydrogen-powered aircraft are also under development.

- **Keypoints**
    - Diamond Aircraft models (42, 40, 60, 62) use diesel engines running on Jet A fuel.
    - Boeing Aerospace E-Flyer is a fully electric prototype.
    - Hybrid and hydrogen-powered aircraft are being explored.
    - Electric propulsion is environmentally friendly but not yet widely adopted.
- **Explanation**
  Hybrid systems combine conventional and electric engines for efficiency and redundancy. Electric and hydrogen propulsion offer environmental benefits but face technical challenges.
- **Examples**
  > Diamond Aircraft uses diesel engines that can run on Jet A fuel, making them popular in Europe due to high fuel prices.

    - Diesel engines are more fuel-efficient.
    - Jet A fuel is widely available at airports.
- **Considerations**
- Monitor developments in hybrid and electric propulsion.
- Consider fuel availability and cost in engine selection.

Firewall Function in Aircraft

> The firewall is a metal wall behind the engine, made of fire-resistant material, designed to protect the cockpit and occupants from engine fires.

- **Keypoints**
  - Firewall is made of special, fire-resistant metal.
  - Prevents fire from reaching cockpit.
  - Essential safety feature in single-engine aircraft.
- **Explanation**
  In case of engine fire, the firewall acts as a barrier, preventing flames and heat from entering the passenger compartment.
- **Examples**
  > A single-engine aircraft has a firewall separating the engine compartment from the cockpit, ensuring pilot safety in case of fire.

  - Engine fire occurs.
  - Firewall prevents fire from spreading to cockpit.
- **Considerations**
- Inspect firewall integrity during maintenance.
- **Special Circumstances**
- If encountering an engine fire, how should it be addressed? Rely on the firewall for protection, shut down the engine, and follow emergency procedures.

Engine Mounting and Bulkhead

> The engine is mounted in a tubular steel frame called the engine mounting frame, which joins the fuselage at the bulkhead. The bulkhead acts as a firewall, providing a barrier between the engine and the rest of the aircraft.

- **Keypoints**
  - Engine mounting frame is made of tubular steel.
  - The frame is called the engine mounting frame.
  - The engine mounting joins the fuselage at the bulkhead.
  - The bulkhead acts as a firewall.
- **Explanation**
  The engine is secured within a steel frame, which is then attached to the aircraft's fuselage at a structural partition known as the bulkhead. This bulkhead serves as a firewall, protecting the rest of the aircraft from potential engine fires.

Manifold Pressure in Piston Engines

> Manifold pressure is the pressure measured in the induction manifold of a piston engine. In a normally aspirated engine (without supercharger or turbocharger), this pressure is determined by the outside air pressure and the throttle position.

- **Keypoints**
  - Manifold pressure is measured in the induction manifold.
  - Normally aspirated engines do not have superchargers or turbochargers.
  - Manifold pressure depends on outside air pressure and throttle position.
  - High manifold pressure indicates high engine power (high RPM).
  - Low manifold pressure indicates low engine power (low RPM).
  - At sea level, with throttle fully open, manifold pressure is around 26 inches of mercury in an average training aircraft.
  - As altitude increases, manifold pressure decreases even with throttle fully open.
- **Explanation**
  The induction manifold is the compartment where the fuel-air mixture is present before entering the engine cylinders. The pressure here, called manifold pressure, is a key indicator of engine power. At sea level, with the throttle fully open, the manifold pressure can reach about 26 inches of mercury. As the aircraft climbs and outside air pressure drops, the manifold pressure also drops, reducing engine power.
- **Examples**
  > With the throttle fully open at sea level, the manifold pressure in an average training aircraft is around 26 inches of mercury. As the aircraft climbs, even if the throttle remains fully open, the manifold pressure decreases due to lower outside air pressure.

  - At sea level, outside air pressure is highest, so manifold pressure can reach its maximum (26 inches of mercury).
  - As the aircraft ascends, outside air pressure drops, so less air enters the induction manifold, lowering manifold pressure.
  - Lower manifold pressure means less power output from the engine.
- **Considerations**
- Monitor manifold pressure during climb to avoid power loss.
- Understand the relationship between throttle position and manifold pressure.

Supercharger and Turbocharger in Aircraft Engines

> A supercharger is a compressor that increases the manifold pressure at all altitudes, thereby increasing engine power. It is driven by the engine and uses a blower impeller to accelerate the fuel-air mixture. The turbocharger is a development of the supercharger, often called a turbocharger, and further improves performance.

- **Keypoints**

- Supercharger is a compressor for increasing manifold pressure.
    - It is driven by the engine via a shaft.
    - The blower impeller accelerates the mixture, increasing its velocity and pressure.
    - High pressure mixture is directed to the cylinders.
    - Superchargers can be single speed, two speed, or variable speed.
    - Turbocharger is an advancement of the supercharger.
    - Over-boosting at low altitude can damage the engine.
    - Supercharger operation involves centrifugal compressor and diffusers.
- **Explanation**
  The supercharger compresses the fuel-air mixture before it enters the engine cylinders, increasing manifold pressure and thus engine power, especially at higher altitudes where outside air pressure is low. The impeller (centrifugal compressor) spins at high speed, driven by the engine, and the mixture passes through diffusers where velocity is converted to pressure. Care must be taken not to over-boost the engine at low altitudes, as the denser air can cause excessive pressure and potential engine damage. The turbocharger further improves this process, often being engine-driven and automatically adjusting to conditions.
- **Examples**
  > The lecturer references the Toyota Supra, a car known for being supercharged and turbocharged, achieving up to 1,000 horsepower. Similarly, in aircraft engines, adding a supercharger or turbocharger greatly increases power, especially at high altitudes.

    - Superchargers and turbochargers compress the intake air, allowing more fuel to be burned and increasing power.
    - In aircraft, this compensates for the loss of air density at altitude.
    - In cars like the Toyota Supra, it results in very high horsepower.
- **Considerations**
- Avoid over-boosting the engine at low altitudes to prevent damage.
- Follow POH FM (Pilot’s Operating Handbook/Flight Manual) for manifold pressure settings at different altitudes.
- Understand the construction and operation of superchargers and turbochargers.
- **Special Circumstances**
- If encountering over-boosting at low altitude, reduce manifold pressure according to POH FM guidelines to prevent engine damage.

Construction and Operation of Supercharger

> A supercharger consists of a tube for the mixture, a blower impeller (centrifugal compressor), diffusers, and an engine-driven shaft. The impeller accelerates the

> mixture, which then passes through diffusers where velocity is converted to pressure before entering the cylinders.

- **Keypoints**
  - Mixture enters through a tube.
  - Blower impeller (centrifugal compressor) accelerates the mixture.
  - Diffusers convert velocity to pressure.
  - Engine-driven shaft powers the impeller.
  - High pressure mixture is delivered to the cylinders.
- **Explanation**
  The supercharger's impeller, powered by the engine, spins rapidly to accelerate the fuel-air mixture. As the mixture exits the impeller, it enters diffusers where its velocity is reduced and pressure is increased. This high-pressure mixture is then sent to the engine cylinders, improving power output.
- **Considerations**
- Understand the flow of mixture through the supercharger components.
- Recognize the importance of each part (impeller, diffusers, shaft) in increasing manifold pressure.

Turbocharger Operation and Critical Altitude

> A turbocharger uses a turbine driven by exhaust gas pressure to drive a compressor in the intake manifold. It provides a set maximum manifold pressure up to a certain density altitude called the critical altitude (around 25,000 feet). Above this altitude, manifold pressure declines with reducing air density.

- **Keypoints**
  - Turbocharger is driven by exhaust gas pressure.
  - Provides maximum manifold pressure up to critical altitude.
  - Critical altitude is around 25,000 feet.
  - Above critical altitude, manifold pressure and horsepower decrease.
  - Turbocharged engines maintain horsepower up to critical altitude, unlike normally aspirated engines.
- **Explanation**
  The turbocharger compensates for decreasing air density as altitude increases by compressing intake air. This allows the engine to maintain power output up to the critical altitude. Beyond this point, the turbocharger cannot compensate further, and power drops.
- **Examples**
  > At 25,000 feet, a normally aspirated engine's power drops to approximately half (around 110 horsepower instead of 200), while a turbocharged engine maintains the same horsepower up to 25,000 feet.

    - As altitude increases, air density decreases, reducing available oxygen for combustion.
    - A turbocharger compresses intake air, maintaining manifold pressure and engine power.
    - At critical altitude (25,000 feet), the turbocharger reaches its limit; above this, power decreases.
- **Considerations**
- Be aware of the critical altitude for your engine.
- Understand that above critical altitude, power will decrease regardless of turbocharging.
- **Special Circumstances**
- If operating above 25,000 feet, expect a reduction in horsepower even with a turbocharger.

Wastegate Function in Turbocharged Engines

> A wastegate is a pressure relief valve in turbocharged engines that prevents excessive manifold pressure, especially during takeoff, by opening to depressurize the system.

- **Keypoints**
    - Prevents overboost by opening to release excess pressure.
    - Operates automatically to maintain safe manifold pressure.
    - Protects engine from damage due to excessive pressure.
- **Explanation**
  The wastegate opens when manifold pressure exceeds a set limit, diverting exhaust gases away from the turbine and reducing boost.
- **Examples**
  > During takeoff, manifold pressure can rise rapidly. The wastegate opens to prevent overboost, ensuring safe engine operation.

    - High throttle settings increase exhaust pressure.
    - Wastegate senses manifold pressure and opens as needed.
    - Prevents engine damage from excessive boost.
- **Considerations**
- Monitor manifold pressure during takeoff and climb.
- Ensure wastegate is functioning properly during pre-flight checks.
- **Special Circumstances**
- If the wastegate fails to open, reduce throttle to prevent overboost.

Engine Designators and Their Meanings

> Aircraft engines use letter designators to indicate features: G (gear), O (opposed), I (fuel injected), S (supercharged), T (turbocharged), AE (aerobatic engine), H (helicopter use), V (vertically mounted).

- **Keypoints**
  - G: Gear
  - O: Opposed
  - I: Fuel injected
  - S: Supercharged
  - T: Turbocharged
  - AE: Aerobatic engine
  - H: Helicopter use
  - V: Vertically mounted
- **Explanation**
  Engine model numbers combine these letters to describe engine features. For example, T-S-I-O-550-K means turbocharged, supercharged, fuel injected, opposed, 550 cubic inch displacement.
- **Examples**
  > T: Turbocharged, S: Supercharged, I: Fuel injected, O: Opposed, 550: cubic inch displacement, K: model variant.

  - Each letter indicates a specific engine feature.
  - The number provides displacement or power information.
- **Considerations**
- Know the meaning of each designator for exam and practical purposes.

Four-Stroke Engine Cycle and Crankshaft Rotation

> A four-stroke engine cycle consists of intake, compression, explosion (power), and exhaust. During one complete cycle, the crankshaft makes two full rotations.

- **Keypoints**
  - Four strokes: intake, compression, explosion, exhaust.
  - Piston moves down (intake), up (compression), down (explosion), up (exhaust).
  - Crankshaft completes two full rotations per cycle.
  - Camshaft turns at half the speed of the crankshaft.
- **Explanation**
  Each stroke corresponds to a half rotation of the crankshaft. Two rotations complete all four strokes. The camshaft, which operates the valves, rotates once for every two crankshaft rotations.
- **Examples**

> During one complete cycle in a four-stroke engine, the crankshaft will have made two full rotations.

  - Intake: piston down, crankshaft rotates half turn.
  - Compression: piston up, another half turn.
  - Explosion: piston down, another half turn.
  - Exhaust: piston up, another half turn.
  - Total: two full rotations.
- **Considerations**
- Remember the relationship between crankshaft and camshaft speeds.

Detonation in Aircraft Engines

> Detonation is the uncontrolled and explosive burning of fuel within a cylinder, causing engine damage.

- **Keypoints**
  - Detonation is random and uncontrolled combustion.
  - Can cause severe engine damage.
  - Usually results from improper fuel mixture or excessive temperature/pressure.
- **Explanation**
  Detonation occurs when fuel-air mixture ignites prematurely or unevenly, creating shock waves and high pressures inside the cylinder.
- **Examples**
  > Detonation is defined as uncontrolled and explosive burning of fuel causing damage.

  - Occurs when combustion is not smooth.
  - Can be identified by knocking or pinging sounds.
- **Considerations**
- Monitor engine temperature and mixture to prevent detonation.
- **Special Circumstances**
- If detonation is suspected, reduce power and enrich mixture immediately.

Compression Ratio

> Compression ratio is the ratio of the total volume of the cylinder when the piston is at the bottom of its stroke to the volume when the piston is at the top.

- **Keypoints**
  - Higher compression ratios generally increase engine efficiency.
  - Too high a ratio can lead to detonation.

Air-Cooled Engine Temperature Regulation

> Air-cooled aircraft engines regulate temperature using a cowling that directs airflow around the cylinders, often with baffles.

- **Keypoints**
  - Cowling and baffles direct air to cool engine cylinders.
  - Proper airflow is essential for engine cooling.
- **Considerations**
- Ensure cowling and baffles are intact and unobstructed.

Fuel System Types: Gravity Feed and Pump Feed

> Aircraft fuel systems can be gravity feed (fuel tank above carburetor, no pump needed) or pump feed (fuel tank below engine, pump required).

- **Keypoints**
  - Gravity feed relies on gravity to move fuel to engine.
  - Pump feed uses a fuel pump to deliver fuel from tanks below engine.
- **Explanation**
  In gravity feed systems, fuel flows naturally due to elevation difference. In pump feed systems, a mechanical or electric pump is necessary.
- **Examples**
  > Cessna: gravity feed, tank above carburetor, pump usually not used. Cruiser: tanks below engine, pump required.

  - Gravity feed is simpler, fewer moving parts.
  - Pump feed allows more flexible tank placement.
- **Considerations**
- Know your aircraft's fuel system type for troubleshooting.

Fuel Tank Types: Simple, Wet Wing, Bladder, External

> Fuel tanks can be simple aluminum shells, wet wings (integral to wing structure), bladders (rubberized bags), or external tanks (wingtip or under fuselage).

- **Keypoints**
  - Simple tanks: aluminum shells bolted in.
  - Wet wings: fuel stored within sealed wing structure.
  - Bladders: flexible rubberized bags, expand as filled.
  - External tanks: mounted on wingtips or under fuselage.
- **Explanation**
  Different tank types offer trade-offs in capacity, weight, and complexity. Wet wings

and bladders are common in larger or specialized aircraft.

- **Examples**
  > External tanks under wings or fuselage, often mistaken for bombs, are used to increase fuel capacity.

  - External tanks can be jettisoned if needed.
  - Used for extended range or special missions.
- **Considerations**
- Balance fuel tanks to maintain aircraft stability.
- Check for leaks or damage, especially in external tanks.

Fuel Tank Venting and Its Importance

> Proper venting is vital to prevent vacuum formation in fuel tanks, which would stop fuel flow and cause engine failure. Venting allows air to replace fuel as it is consumed.

- **Keypoints**
  - Venting prevents vacuum and fuel starvation.
  - Gravity feed systems are especially dependent on proper venting.
  - Blocked vents can cause engine failure despite fuel being present.
- **Explanation**
  As fuel is used, air must enter the tank to replace it. If the vent is blocked, a vacuum forms, stopping fuel flow. Vents are usually metal pipes under the wing or in the fuel cap.
- **Examples**
  > If a vent pipe is blocked (e.g., by a bug), fuel will stop flowing to the carburetor, causing engine shutdown.

  - Vacuum forms in tank.
  - No fuel reaches engine.
  - Engine stops despite fuel in tank.
- **Considerations**
- Always check venting during pre-flight inspection.
- Use vented fuel caps as required.
- **Special Circumstances**
- If fuel starvation occurs with fuel present, check for blocked vents.

Difference Between Fuel Starvation and Fuel Exhaustion

> Fuel starvation occurs when there is fuel in the tanks but it cannot reach the engine (e.g., due to blocked vent). Fuel exhaustion means there is no fuel left in the tanks.

- **Keypoints**
  - Fuel starvation: fuel present, but not delivered to engine.
  - Fuel exhaustion: no fuel left in tanks.
- **Explanation**
  Fuel starvation is often preventable with proper pre-flight checks. Fuel exhaustion is a result of poor fuel management.
- **Examples**
  > Ensuring vents are clear prevents fuel starvation. Monitoring fuel quantity prevents exhaustion.

  - Blocked vent = starvation.
  - Empty tanks = exhaustion.
- **Considerations**
- Always check both fuel quantity and venting.

Fuel Tank Drains and Contamination Checks

> Fuel tanks have drains to allow sampling and checking for contamination, especially water. The most common contamination is water from condensation or poor sealing.

- **Keypoints**
  - Drains allow fuel samples to be taken.
  - Check for water or debris in fuel.
  - Water contamination common after cold weather or rain.
- **Explanation**
  Use a bayonet-type fuel drainer and a clear bottle to check fuel. Water will separate from fuel and can be seen in the sample.
- **Examples**
  > After a cold night, instructor found fuel tanks full of water due to condensation. Flight was cancelled to drain and clean tanks.

  - Cold weather increases condensation risk.
  - Always check for water before flight.
- **Considerations**
- Always drain and check fuel before flight, especially after rain or cold weather.
- **Special Circumstances**
- If water is found in tanks, do not fly until tanks are drained and refilled with clean fuel.

Priming System and Cold Weather Starting

> The priming system injects fuel directly into the cylinders to aid starting, especially in cold weather when normal starting may be difficult.

- **Keypoints**
  - Primer is a lever that injects fuel into cylinders.
  - Used when engine is cold and difficult to start.
  - Not the same as the fuel pump.
- **Explanation**
  Cold engines may not vaporize fuel efficiently. Priming ensures enough fuel is present for ignition.
- **Examples**
  > In cold weather, use the primer before starting to inject fuel directly into the cylinders.

  - Improves starting reliability in cold conditions.
- **Considerations**
- Do not over-prime, as this can flood the engine.

Water Contamination in Fuel Tanks

> Water is heavier than fuel and collects at the bottom of the fuel tank. If the aircraft is not level or if there are wrinkles/holes in rubber fuel cells, water may not reach the fuel drain, leading to potential engine failure.

- **Keypoints**
  - Water sinks below fuel due to higher density.
  - Fuel drains are located at the lowest point of the tank.
  - If the aircraft is not level, water may not be at the drain point.
  - Rubber fuel cells can trap water away from the drain.
  - Reciprocating engines cannot run on water-contaminated fuel.
  - Water contamination can cause engine power loss, especially after takeoff.
  - In 90% of cases, engines will not start if water is present in the tanks.
- **Explanation**
  The instructor explains that water, being heavier than fuel, settles at the bottom of the tank. During pre-flight checks, draining fuel into a clear bottle and observing for a clear layer (water) beneath the blue Avgas 100 ml fuel helps detect contamination. Aircraft parked unlevel or with rubber fuel cells may not allow water to reach the drain, risking undetected contamination. Water in the fuel can cause engine failure, often immediately after takeoff.
- **Examples**
  > When draining fuel into a plastic bottle and holding it up to the sunlight, any water present will appear as a clear liquid at the bottom, with the blue Avgas

> 100 ml fuel on top.

  - Drain fuel sample into a clear bottle.
  - Hold up to sunlight.
  - Observe for two layers: clear (water) at the bottom, blue (fuel) on top.
  - If water is present, do not fly until contamination is resolved.
- **Considerations**
- Always check for water contamination during pre-flight.
- Ensure aircraft is level when draining fuel.
- Be aware of rubber fuel cell design limitations.
- **Special Circumstances**
- If the aircraft is parked unlevel, water may not be at the drain point—move the aircraft or check multiple drains.
- If using rubber fuel cells, inspect for water trapped in wrinkles or holes.

Fuel Selector Operation and Procedures

> The fuel selector allows the pilot to choose which tank supplies fuel to the engine. Some aircraft have ‘left’, ‘right’, and ‘both’ options, while others (like the cruiser) only have ‘left’ and ‘right’. Standard procedure is to switch tanks every 30 minutes to balance fuel consumption.

- **Keypoints**
  - Cessna selectors: left, right, both.
  - Cruiser selectors: left, right (no both).
  - Switch tanks every 30 minutes to balance weight.
  - Forgetting to switch tanks can cause fuel starvation and engine failure.
  - Design limitations prevent ‘both’ option in some aircraft due to pump requirements.
- **Explanation**
  The instructor describes the operation of fuel selectors in different aircraft. In the cruiser, the selector must be switched every 30 minutes to balance fuel consumption between tanks. Not switching can lead to one tank running dry and engine failure (fuel starvation). The ‘both’ option is not available in some aircraft due to design and pump limitations.
- **Examples**
  > A pilot forgets to switch tanks during flight in a cruiser, drains the right tank, and the engine stops due to fuel starvation.

  - Pilot flies with selector on right tank.
  - Fails to switch to left after 30 minutes.

    - Right tank empties, engine stops.
    - This is called fuel starvation.
- **Considerations**
- Follow standard procedure: switch tanks every 30 minutes.
- Understand your aircraft's fuel selector design.
- Be aware of the consequences of fuel starvation.
- **Special Circumstances**
- If you forget to switch tanks and the engine stops, immediately switch to the other tank and attempt restart.

Fuel Pumps: Electrical and Engine-Driven

> Aircraft may have both engine-driven and electrical fuel pumps. The electrical pump is used for starting, switching tanks, and as a backup during takeoff, landing, or engine-driven pump failure.

- **Keypoints**
    - Electrical pump operated by cockpit switch.
    - Used for starting, tank switching, and backup.
    - Turn on electrical pump during takeoff, landing, and aerobatics.
    - In hot weather, fuel pressure indications may be inaccurate.
- **Explanation**
  The instructor recounts a personal experience where, in hot weather, the fuel pressure gauge indicated zero despite the engine running. The electrical pump was cycled, but the indication persisted. Instructors later explained this is a known issue in hot weather and not necessarily a cause for alarm.
- **Examples**
  > During a flight in Vitoria, the instructor experienced a zero fuel pressure indication at 300 meters above the runway. Despite attempts to resolve it, the indication persisted, but the engine continued running. Instructors later explained this is a common mis-indication in hot weather.

    - Fuel pressure drops to zero on gauge.
    - Electrical pump cycled, no change.
    - Engine continues to run.
    - Instructors confirm it's a known hot weather issue.
- **Considerations**
- Always use the electrical pump as backup during critical phases.
- Be aware of possible false low-pressure indications in hot weather.
- **Special Circumstances**

- If low fuel pressure is indicated in hot weather but the engine runs normally, continue flight but remain vigilant.

Fuel Measurement Systems

> Aircraft use various systems to measure fuel quantity: mechanical floats, electrical senders, electromagnetic sensors, and fuel totalizers. Accuracy is affected by aircraft attitude and maneuvers.

- **Keypoints**
  - Mechanical float systems linked to cockpit indicators.
  - Electrical senders change voltage based on float position.
  - Electromagnetic sensors provide alternative measurement.
  - Fuel totalizers use flow transducers to calculate remaining fuel.
  - Fuel gauges are only rough guides, especially during maneuvers.
- **Explanation**
  The instructor explains that fuel gauges may fluctuate during flight maneuvers due to fuel sloshing. Modern aircraft may use totalizers for more accurate readings, but pilots should always visually check fuel levels during pre-flight.
- **Examples**
  > During maneuvers in a cruiser, the instructor observed fuel quantity readings rapidly changing from 20 to 30, or 30 to 10, due to fuel movement in the tank.

  - Aircraft banks or turns.
  - Fuel shifts in tank.
  - Float drops or rises, causing gauge to fluctuate.
- **Considerations**
- Do not rely solely on fuel gauges; always perform visual checks.
- Understand the limitations of your aircraft's fuel measurement system.
- **Special Circumstances**
- If fuel gauge readings fluctuate during flight, cross-check with time and consumption calculations.

Pre-Flight Fuel Checks

> Pilots must visually check fuel levels in both tanks before flight and confirm with cockpit displays. Fuel quantity and consumption rates should be referenced from the POH/FM.

- **Keypoints**
  - Open fuel caps and visually inspect both tanks.
  - Confirm fuel quantity on cockpit displays.

  - Reference POH/FM for tank capacities and consumption rates.
  - Cruiser: 18 liters/hour consumption, 90 liters total, 5 hours 30 minutes endurance.
- **Explanation**
  The instructor emphasizes the importance of visually checking both tanks and confirming with cockpit instruments. For the cruiser, full tanks provide more than enough fuel for scheduled flights, but minimum fuel requirements for exams must be known.
- **Examples**
  > Before departure, the pilot opens both wing fuel caps, visually confirms full tanks, and checks the cockpit display for matching indications.

  - Open left and right fuel caps.
  - Visually inspect for full tanks.
  - Check cockpit fuel display.
  - Cross-reference with POH/FM.
- **Considerations**
- Always check both tanks, not just one.
- Know your aircraft's fuel consumption and capacity.
- **Special Circumstances**
- If visual and instrument readings do not match, investigate before flight.

Usable vs. Unusable Fuel

> Total fuel capacity includes both usable and unusable fuel. Usable fuel can be drawn by the pump; unusable fuel remains trapped and cannot be used by the engine.

- **Keypoints**
  - Usable fuel: can be pumped to engine.
  - Unusable fuel: trapped in tank, cannot be used.
  - Cruiser: 2 liters unusable (1 liter per tank).
  - POH/FM lists total capacity as usable + unusable.
- **Explanation**
  The instructor explains that unusable fuel is left in the tank after the pump can no longer draw it. It is included in total capacity figures and is used for draining and contamination checks.
- **Examples**
  > Each cruiser tank holds 45 liters: 44 liters usable, 1 liter unusable. Total for both tanks: 90 liters (88 usable, 2 unusable).

  - Check POH/FM for tank capacities.

    - Understand difference between usable and unusable fuel.
- **Considerations**
- Plan flights based on usable fuel only.
- Be aware of unusable fuel for contamination checks.
- **Special Circumstances**
- If fuel is low, do not rely on unusable fuel to reach destination.

Fuel Grades and Octane Ratings

> Aviation gasoline (Avgas) is graded by octane rating, which measures anti-detonation characteristics. Using fuel with a lower octane rating than approved risks detonation; higher octane can cause lead deposits.

- **Keypoints**
    - Avgas 100 LL (blue) is commonly used.
    - Octane rating measures anti-detonation properties.
    - Do not use fuel with lower octane than approved.
    - Higher octane may cause lead deposits on spark plugs.
    - Avgas and Jet A1 are not interchangeable.
- **Explanation**
  The instructor details the importance of using the correct fuel grade as specified in the POH. Using the wrong fuel can cause engine failure or damage.
- **Examples**
  > Avgas 100 LL is used in general aviation. Jet A1 is for turbine or diesel engines. Using Jet A1 in a cruiser will prevent the engine from starting.

    - Check POH for approved fuel.
    - Do not mix or substitute fuel types.
- **Considerations**
- Always verify fuel grade before refueling.
- Understand consequences of incorrect fuel use.
- **Special Circumstances**
- If unsure about fuel type, consult POH or instructor before flight.

Legal and Safety Implications of Insufficient Fuel

> Flying with insufficient fuel is illegal and dangerous. Pilots must always ensure adequate fuel for the planned flight plus reserves.

- **Keypoints**
    - Departing with less than full tanks can lead to emergencies.
    - Running out of fuel may result in license suspension and fines.

    - Always check fuel before and during flight.
- **Explanation**
  The instructor shares an example of a student who returned with almost no fuel, risking legal consequences and safety.
- **Examples**
  > A student flew from Burgos to Santander and back with only slightly more than half tanks. Upon return, the tanks were nearly dry, which is illegal and dangerous.

    - Always plan for adequate fuel.
    - Check fuel before and during flight.
- **Considerations**
- Never depart with insufficient fuel.
- Monitor fuel throughout the flight.
- **Special Circumstances**
- If delayed in flight and fuel is low, consider diverting or landing as soon as possible.

In-Flight Fuel Monitoring

> Pilots must constantly monitor fuel quantity, consumption rate, and remaining flight time to maintain situational awareness and safety.

- **Keypoints**
    - Check fuel quantity and time remaining regularly.
    - Calculate range based on current consumption.
    - Cross-check with planned route and reserves.
- **Explanation**
  The instructor emphasizes the importance of ongoing fuel monitoring to avoid running out and to make informed decisions during flight.
- **Examples**
  > Pilot notes 70 liters remaining, with a consumption rate of 18 liters/hour, giving approximately 4 hours of flight time.

    - Monitor fuel gauge.
    - Calculate time and range remaining.
    - Adjust plans as needed.
- **Considerations**
- Regularly check fuel status during flight.
- Be proactive in decision-making based on fuel.
- **Special Circumstances**
- If fuel drops below reserve, land at the nearest suitable airport.

Use of Mogas in Aircraft

> Some general aviation aircraft are approved to use motor gasoline (mogas) from automotive stations. Approval must be checked in the POH.

- **Keypoints**
  - Not all aircraft can use mogas.
  - Check POH for approval before using mogas.
  - Mogas is typically 92 octane or similar.
- **Explanation**
  The instructor explains that if the POH approves, pilots can use mogas from automotive stations, but must verify approval first.
- **Examples**
  > A pilot with a cruiser approved for mogas can refuel at a CEPSA station with 92 octane, after confirming approval in the POH.

  - Check POH for mogas approval.
  - Refuel with appropriate grade if approved.
- **Considerations**
- Never use mogas unless explicitly approved.
- Verify octane rating matches requirements.
- **Special Circumstances**
- If only mogas is available and not approved, do not refuel or fly.

Assignments & Suggestions

- Complete the progress test at home every month and show it to the instructor the next day, as it is mandatory.
- Study the topics covered in class at home after today’s early finish.
- Watch the videos shared by the instructor about jet airplane and Cessna construction.
- Read the provided material at home (2000 characters) for further understanding.
- Complete the quiz together in class; answers will be reviewed and can be entered into the system later.
- Review the SOP procedure course for further details on magneto testing.
- At home, slowly read through the slide on mechanical components and write down definitions, especially regarding the connection between the crankshaft and propeller, and the speed relationship between crankshaft and camshaft.
- Go through the 3D engine animation to study and identify all components.
- Read two to five slides by yourself if the lesson is not finished by 8.

- Prepare for a progress test after the fourth lesson.
- Always perform pre-flight checks for fuel tank venting and contamination.
- Read the three pages assigned by the instructor before the next class. If you do not understand anything, ask the instructor for clarification.