2025-05-08 - AGK Lecture 3

> Date & Time: 2025-05-08 15:19:32
> Location: [Insert Location]
> [Insert Title]
> `Aircraft Engine Systems` `Induction and Ignition` `Aircraft Structures`

Theme

This lecture provides an in-depth overview of aircraft engine systems, including induction, carburetion, ignition, cooling, and oil systems, as well as structural elements such as wings, landing gear, and composite materials. It covers troubleshooting, pre-flight checks, and operational procedures, with practical examples and considerations for flight safety and maintenance. The session also addresses modern technologies like FADEC and differences between engine types, emphasizing both theoretical principles and hands-on applications.

Takeaways

1. Lesson 6 of 16 big lessons, with 7 cards for this lesson
2. Preparation for exams using quizzes and progress tests (e.g., 23 questions for landing gear, wheels, tires, and brakes; 1 question for anti-icing system; 15 questions for progress test)
3. AGK (Aircraft General Knowledge) to be finished on Monday, with POF (Principles of Flight) starting the same day
4. Induction system: components, function, and Bernoulli's principle
5. Carburetor structure: venturi tube, float chamber, butterfly valve, accelerator pump
6. Mixture control: stoichiometric ratio, rich/lean mixtures, manual adjustment
7. Icing in induction system: impact icing and carburetor venturi icing, conditions for occurrence
8. Temperature drop in venturi can be up to 30 degrees
9. Aircraft not certified for known icing conditions
10. Practical troubleshooting: recognizing carburetor icing by RPM fluctuations and using carburetor heat

Highlights

- `"The higher the airflow speed, the lower the air pressure. This is the Bernoulli's theorem."`
- `"The greater the water content of the air at given temperatures, the greater the risk of carburetor icing."`
- `"Visible water droplets, such as clouds, fog, or precipitation, do not have to be present for carburetor icing to occur."`
- `"Full rich mixture equals great cooling."`
- `"Everything has its own advantages and disadvantages."`
- `"Viscosity is a measure of how readily any fluid will flow. So basically how thick it is."`
- `"This is the reason why we always perform smooth and never abrupt maneuvering."`

Chapters & Topics

Induction System and Bernoulli's Principle

> The induction system in aircraft engines consists of components such as the air filter, air intake, carburetor, and engine. Bernoulli's principle states that in a venturi tube, the local velocity of airflow is higher in the narrow section, and the pressure is lower compared to the wider sections. This principle is fundamental to the operation of the carburetor, where the venturi effect causes a pressure drop that draws fuel from the float chamber into the airflow.

- **Keypoints**
  - Induction system components: air filter, air intake, carburetor, engine
  - Venturi tube: narrow throat increases airflow speed, decreases pressure
  - Bernoulli's principle: higher velocity = lower pressure in the venturi
  - Pressure drop in venturi draws fuel from float chamber
- **Explanation**
  The instructor used diagrams and step-by-step explanations to show how airflow enters the induction system, passes through the air filter, and then through the venturi in the carburetor. The pressure drop in the venturi, as explained by Bernoulli's principle, causes fuel to be sucked from the float chamber into the airflow, mixing with air before entering the engine.
- **Examples**
  > A tube with a narrow throat (venturi) is used to demonstrate airflow. When air is pushed through the tube, it speeds up in the narrow section, causing a pressure drop. This is analogous to the venturi in a carburetor, where the pressure drop draws fuel into the airflow.

    - Draw a venturi tube with a narrow middle section.
    - Show airflow entering the tube and speeding up in the narrow section.
    - Explain that the pressure in the narrow section drops.
    - Relate this to the carburetor, where the pressure drop draws fuel from the float chamber.
- **Considerations**
- Understanding the relationship between airflow speed and pressure is essential for troubleshooting fuel delivery issues.
- **Special Circumstances**
- If the venturi becomes blocked or airflow is restricted, fuel delivery to the engine may be compromised, leading to engine performance issues.

Carburetor Structure and Function

> The carburetor contains a venturi tube, float chamber, butterfly valve, and accelerator pump. The venturi creates a pressure drop to draw fuel. The butterfly valve regulates the mixture flow and is connected to the throttle. The accelerator pump injects extra fuel during rapid throttle movements to prevent engine hesitation.

- **Keypoints**
    - Venturi tube creates pressure drop for fuel delivery
    - Float chamber stores fuel before it enters the venturi
    - Butterfly valve regulates mixture flow and engine power
    - Accelerator pump prevents delay in power delivery during rapid throttle changes
- **Explanation**
  The instructor described how the carburetor’s venturi draws fuel from the float chamber. The butterfly valve, controlled by the throttle, adjusts the amount of mixture entering the engine. The accelerator pump injects a shot of fuel when the throttle is opened quickly, preventing hesitation or engine shutdown.
- **Examples**
  > When the throttle is rapidly moved from idle to full power, the accelerator pump injects extra fuel into the venturi to prevent a lag in engine response.

    - Throttle is moved quickly from idle to full power.
    - Without the accelerator pump, there would be a delay in fuel delivery, causing engine hesitation.
    - The accelerator pump injects a shot of fuel, eliminating the delay and ensuring immediate power response.
- **Considerations**
- Proper adjustment of the accelerator pump and butterfly valve is crucial for smooth engine operation.

- **Special Circumstances**
- If the accelerator pump is malfunctioning, rapid throttle movements may cause engine hesitation or shutdown.

Mixture Control and Stoichiometric Ratio

> Mixture control allows the pilot to adjust the fuel-to-air ratio. The ideal (stoichiometric) ratio is 1 part fuel to between 12 and 15 parts air, typically 1 to 15. A rich mixture (more fuel) increases power and aids cooling, while a lean mixture (more air) reduces power. Manual mixture control is preferred in some aircraft, especially at higher altitudes where air density decreases.

- **Keypoints**
  - Stoichiometric ratio: 1 part fuel to 12–15 parts air (usually 1 to 15)
  - Rich mixture: more fuel, more power, aids cooling
  - Lean mixture: more air, less power, better fuel economy
  - Manual mixture control allows adjustment for altitude and engine temperature
- **Explanation**
  The instructor explained that as altitude increases, air density decreases, making the mixture richer if fuel flow is not reduced. Pilots use the mixture control to maintain the correct ratio, optimizing engine performance and preventing power loss.
- **Examples**
  > At higher altitudes, the pilot reduces the fuel flow using the mixture control to maintain the correct air-fuel ratio, as air density is lower.

  - Pilot observes engine performance and cylinder head temperature.
  - If the mixture is too rich at altitude, the engine loses power.
  - Pilot leans the mixture to restore optimal performance.
- **Considerations**
- Monitor cylinder head temperature (CHT) and adjust mixture as needed.
- Refer to the aircraft's performance section for recommended mixture settings at various altitudes.
- **Special Circumstances**
- If engine temperature rises excessively, enrich the mixture to aid cooling.
- If operating at high altitude, lean the mixture to prevent power loss and excessive fuel consumption.

Icing in Induction System

> Icing can occur in the induction system as impact icing (ice forming on the air intake and filter) or carburetor venturi icing (ice forming within the venturi). Impact icing

> typically occurs in visible moisture and temperatures below around +5 degrees. Carburetor icing can occur in any weather, even on clear days, due to temperature drops in the venturi (up to 30 degrees). Aircraft used in training are generally not certified for known icing conditions.

- **Keypoints**
  - Impact icing: ice forms on air intake/filter, blocks airflow
  - Carburetor venturi icing: ice forms in venturi, can occur in any weather
  - Temperature in venturi can drop by 30 degrees
  - Carburetor icing suspected if RPM fluctuates or drops
  - Use carburetor heat to melt ice and restore engine performance
- **Explanation**
  The instructor described how pressure drops in the venturi cause temperature drops, leading to condensation and possible ice formation. Carburetor icing is detected by irregular or dropping RPM. The solution is to apply carburetor heat and wait for the ice to melt.
- **Examples**
  > While flying at 7,000 feet with an outside temperature near zero, the temperature in the venturi can drop by 30 degrees, causing ice to form and engine RPM to fluctuate.

  - Pilot notices RPM fluctuating or dropping.
  - Suspects carburetor icing.
  - Applies carburetor heat.
  - Waits for ice to melt and RPM to stabilize.
- **Considerations**
- Training aircraft are not certified for known icing conditions.
- Always monitor engine RPM for signs of icing.
- Apply carburetor heat promptly if icing is suspected.
- **Special Circumstances**
- If flying in visible moisture and temperature is below +5 degrees, be vigilant for impact icing.
- If carburetor icing occurs, apply carburetor heat and monitor RPM until normal operation resumes.

Carburetor Icing

> Carburetor icing occurs when ice forms inside the carburetor due to a combination of temperature and humidity, potentially leading to engine power loss or failure.

- **Keypoints**

    - Carburetor icing is most likely to occur in temperatures between minus 5 and plus 20 degrees Celsius, but can occur between minus 10 and plus 30 degrees.
    - Relative humidity is a critical factor; higher humidity increases the risk.
    - Carburetor icing can occur even in clear skies, not just in visible moisture.
    - Symptoms include fluctuating RPM (by 200 or 300 RPM), reduction in power during cruise, or unexplained RPM drops.
    - Carburetor heat should be applied when icing is suspected or during descent (low power settings).
- **Explanation**
  Carburetor icing forms as the temperature in the carburetor drops due to fuel vaporization and pressure decrease, causing moisture in the air to freeze. This can block the venturi and reduce engine power. The risk is highest at certain temperature and humidity ranges. Carburetor heat introduces warm, unfiltered air from around the exhaust, melting the ice but causing a drop in RPM due to less dense air.
- **Examples**
  > During cruise at 75% power, if the RPM suddenly drops by 200-300 RPM without throttle adjustment, carburetor icing is suspected. Applying carburetor heat causes a further temporary drop in RPM, then a return to normal if icing was present.

    - Monitor RPM during steady cruise.
    - Notice unexplained RPM drop.
    - Apply carburetor heat.
    - Observe further RPM drop (due to less dense air and melting ice).
    - If RPM returns to normal, icing was present.
- **Considerations**
- Always monitor RPM for unexplained fluctuations.
- Apply carburetor heat during descent or when icing is suspected.
- Do not use carburetor heat during takeoff.
- Carburetor heat uses unfiltered air; avoid ground use unless necessary.
- **Special Circumstances**
- If experiencing RPM fluctuations or power loss without throttle movement, apply carburetor heat immediately.
- If on the ground, only use carburetor heat for engine checks, not prolonged periods.

Carburetor Heat Operation

> Carburetor heat is a control that introduces hot, unfiltered air from around the exhaust into the carburetor to melt ice and prevent icing.

- **Keypoints**
  - Activating carburetor heat causes a reduction in RPM due to less dense air.
  - If icing is present, RPM may fluctuate or increase after heat is applied.
  - Manufacturer recommendations vary: some require heat below 2000 RPM, others only when power drops are noticed.
  - Carburetor heat should not be used during takeoff or unnecessarily on the ground.
- **Explanation**
  Carburetor heat is used to prevent or remove ice by routing hot air from the exhaust into the carburetor. This air is unfiltered, so it should be used sparingly on the ground to avoid engine contamination. The typical temperature rise is around 30 degrees Celsius. The effect on RPM depends on whether ice was present.
- **Examples**
  > During descent, power is reduced and engine cooling increases, raising the risk of carburetor icing. Applying carburetor heat prevents ice formation.

  - Reduce throttle for descent.
  - Engine produces less heat, increasing icing risk.
  - Apply carburetor heat to introduce warm air.
  - Monitor RPM and engine performance.
- **Considerations**
- Follow aircraft-specific procedures for carburetor heat use.
- Check the Pilot Operating Handbook (POH) for manufacturer instructions.
- Be aware of the source of carburetor heat air (unfiltered).
- **Special Circumstances**
- If carburetor heat is needed on the ground, use only for engine checks and minimize duration.

Fuel Injection vs. Carburetor Engines

> Fuel injection engines deliver fuel directly into the cylinder, offering more efficient and powerful operation compared to carburetor engines, which mix fuel and air before entering the cylinder.

- **Keypoints**
  - Fuel injection engines do not have carburetor heat; instead, they have alternate induction air controls.
  - Fuel injection is common in engines of 180 horsepower or more.
  - Carburetor engines are more prone to icing and require more manual intervention.

- **Explanation**
  Fuel injection systems spray fuel directly into the cylinder, ensuring precise mixture and reducing the risk of icing. In case of air intake blockage, alternate induction air is used, which is warmer and less likely to be blocked by ice.
- **Examples**
  > If the normal air inlet is blocked by impact ice, alternate air is selected, feeding air from a separate, warmer pipe within the engine.

  - Detect air intake blockage.
  - Select alternate induction air control.
  - Air is routed from a warmer, internal source.
  - Engine continues to operate without external air intake.
- **Considerations**
- Know the type of engine in your aircraft and the appropriate procedures for air intake blockage.
- Understand that fuel injection engines do not require carburetor heat.
- **Special Circumstances**
- If air intake is blocked in a carburetor engine, use carburetor heat; in a fuel injection engine, use alternate induction air.

Mixture Control and Engine Cooling

> The fuel-to-air mixture affects engine cooling: a rich mixture (more fuel) provides better cooling, while a lean mixture (less fuel) can cause higher cylinder head temperatures.

- **Keypoints**
  - Full rich mixture equals great cooling due to more fuel absorbing engine heat.
  - Lean mixture reduces cooling, increasing cylinder head temperature.
  - If cylinder head temperature rises, enrich the mixture and/or increase airspeed.
- **Explanation**
  A rich mixture means more fuel is present to absorb and carry away heat from the engine, which is especially important during high power or low airflow situations. If the mixture is too lean, less fuel is available to absorb heat, risking engine overheating.
- **Examples**
  > During cruise, if the cylinder head temperature increases, the pilot should enrich the mixture and, if necessary, increase airspeed by descending.

  - Monitor cylinder head temperature.
  - If temperature rises, set mixture to full rich.
  - Wait for engine to cool.

    - If still hot, increase airspeed by descending.
- **Considerations**
- Monitor engine temperature indicators during flight.
- Adjust mixture as needed for cooling.
- Understand the relationship between mixture and engine cooling.
- **Special Circumstances**
- If engine temperature continues to rise despite full rich mixture, increase airspeed and descend.

Pre-Flight Checks for Air Intake and Engine

> Before flight, pilots must check air intakes for blockages and ensure proper engine cooling procedures are followed.

- **Keypoints**
    - Visually inspect air intakes below the propeller and on the right side for blockages (bugs, dust, sand).
    - Check oil level through the small door on the engine.
    - On air-cooled engines, run mixture full rich for cooling when airflow is low.
- **Explanation**
  Pre-flight inspection includes checking all air intakes for obstructions and verifying oil levels. For air-cooled engines, running a rich mixture helps prevent overheating when airflow is insufficient.
- **Examples**
  > Before flight, the pilot checks the air intake below the propeller and on the right side for blockages, and checks oil level through a small door.

    - Visually inspect air intakes for obstructions.
    - Check oil level.
    - Ensure all checks are complete before walk-around.
- **Considerations**
- Always perform a thorough pre-flight inspection.
- Ensure air intakes are clear before flight.
- **Special Circumstances**
- If air intake is blocked and cannot be cleared, do not proceed with the flight.

Priming and Starting Procedures

> Priming involves introducing extra fuel into the engine before starting. Different aircraft use different systems: American aircraft use a primer, while European aircraft like Tecna and Cruiser use a choke.

- **Keypoints**
  - Primer or choke is used to introduce fuel for starting.
  - If the priming pump unlocks in flight, excess fuel may cause engine stall.
  - Throttle adjustment is necessary when disengaging the choke.
- **Explanation**
  Priming ensures there is enough fuel in the engine for starting. In flight, an unlocked primer can flood the engine. The choke in European aircraft serves a similar function to the primer in American aircraft.
- **Examples**
  > The pilot sets the choke, starts the engine, and gradually disengages the choke while adjusting the throttle to maintain RPM.

  - Set choke to on.
  - Start engine.
  - Gradually turn choke off.
  - Adjust throttle as needed to maintain RPM.
- **Considerations**
- Ensure primer or choke is disengaged after engine starts.
- Monitor RPM during start and adjust throttle as needed.
- **Special Circumstances**
- If engine stalls after start, check primer or choke position and adjust accordingly.

Fuel-to-Air Ratios and Mixture Types

> The fuel-to-air ratio determines whether the mixture is rich or lean. The richest mixture is the lowest air-to-fuel ratio (e.g., 1 to 10), while lean mixtures have higher ratios (e.g., 1 to 35).

- **Keypoints**
  - 1 to 10 is richer than 1 to 15 or 1 to 35.
  - Rich mixtures can cause oil deposits on spark plugs.
  - Ideal fuel-air mixture ratio is called stoichiometric.
- **Explanation**
  A lower air-to-fuel ratio means more fuel per unit of air, resulting in a richer mixture. Excessively rich mixtures can foul spark plugs, while lean mixtures can cause overheating.
- **Examples**
  > Given ratios 1:10, 1:15, 1:14.7, 1:13, the richest is 1:10.

  - Compare ratios: lower air number means richer mixture.
  - 1:10 is richest among options.

- **Considerations**
- Use the correct mixture for phase of flight.
- Monitor for signs of spark plug fouling with rich mixtures.
- **Special Circumstances**
- If spark plugs are fouled due to rich mixture, lean the mixture to clean them.

Ignition System in Aircraft Engines

> The ignition system in aircraft engines consists of magnetos, spark plugs, coils, breaker points, capacitors, and distributors. It is responsible for generating and delivering high-voltage electrical current to ignite the fuel-air mixture in the engine cylinders at the correct time. The system is designed for redundancy and independence from the aircraft's main electrical system.

- **Keypoints**
  - Magnetos are self-contained high-voltage generators driven by the engine's crankshaft.
  - The system includes primary and secondary coils; the primary coil generates current, and the secondary coil steps up the voltage.
  - Breaker points open to interrupt current flow, causing the magnetic field to collapse and induce a voltage spike.
  - A capacitor is used to ensure a rapid collapse of the magnetic field, resulting in a strong voltage spike.
  - The distributor routes high-voltage current to each spark plug in the correct firing order.
  - Each cylinder typically has two spark plugs, each powered by a separate magneto for redundancy.
  - High-tension leads (ignition harness) carry the high-voltage current to the spark plugs.
  - The ignition system is independent of the aircraft's electrical system; once the engine is running, the battery and electrical system can be disconnected.
  - Magneto switches in the cockpit control which magnetos are active (OFF, LEFT, RIGHT, BOTH).
- **Explanation**
  The magneto, mechanically linked to the engine's crankshaft, rotates a magnet inside coils to generate electrical current. The primary coil produces current, which is interrupted by breaker points, causing the magnetic field to collapse and induce a high voltage in the secondary coil. A capacitor ensures the field collapses quickly, maximizing the voltage spike. The distributor directs this high voltage to the correct spark plug at the right time. The system is designed so that even if one magneto fails, the engine continues to run on the remaining spark plugs, albeit at reduced power.

- **Examples**
  > The instructor described an incident with a Cessna aircraft, approximately 40-50 years old (built in 1972), where the engine could not be started because the battery was drained. Ground power (a generator running on fuel) had to be connected to the aircraft to start the engine.

  - The battery was low because the aircraft was left on the main battery for too long before starting.
  - Without sufficient battery power, the starter could not turn the engine fast enough for the magnetos to generate the necessary current.
  - Ground power provided the needed energy to start the engine, after which the magnetos took over.
- **Considerations**
- Always start the engine as soon as possible after entering the aircraft to avoid draining the battery.
- Understand the function and independence of the magnetos from the main electrical system.
- Be aware of the switch positions (OFF, LEFT, RIGHT, BOTH) and their effects on the ignition system.
- Recognize the importance of redundancy with two magnetos and two spark plugs per cylinder.
- **Special Circumstances**
- If the battery is drained and the engine cannot be started, connect ground power (a generator) to the aircraft to provide the necessary energy for starting.
- If one magneto fails during flight, the engine will continue to run on the remaining spark plugs, but with reduced power (lower RPM).

Impulse Coupling and Induction Vibrator in Engine Starting

> Impulse coupling and induction vibrator (shower of sparks system) are mechanisms used to aid engine starting by ensuring a strong spark at low engine speeds. Impulse coupling is a mechanical device using a spring to momentarily accelerate the magneto, while the induction vibrator is an electronic system that provides a similar function.

- **Keypoints**
  - Impulse coupling is fitted to one magneto and uses a spring-loaded mechanism to store and rapidly release energy.
  - At low cranking speeds, the spring is wound up and then released, accelerating the magneto to generate a strong spark.
  - Impulse coupling also delays the spark during starting to ensure proper piston movement.

    - Once the engine starts, the impulse coupling disengages and normal spark timing resumes.
    - Induction vibrator (shower of sparks) is an electronic system, usually fitted to the left magneto, that provides repeated sparks during starting.
    - Some aircraft use a key switch for starting, others use a starter button (e.g., Tecnam P-Mentor).
- **Explanation**
  During engine start, the engine turns slowly, and the magnetos cannot generate sufficient current for a strong spark. The impulse coupling stores energy as the engine cranks, then releases it suddenly to spin the magneto faster, producing a hot spark. This also delays the spark to prevent backfiring. The induction vibrator achieves a similar effect electronically, providing multiple sparks until the engine starts and the key is released.
- **Examples**
  > The instructor compared the impulse coupling mechanism to a wind-up toy mouse. The toy's spring is wound up to store potential energy, which is released to make the toy move. Similarly, the impulse coupling stores energy and releases it to spin the magneto rapidly.

    - The analogy helps visualize how the impulse coupling works inside the magneto.
    - Potential energy is stored in the spring during slow cranking.
    - Rapid release of the spring spins the magneto, generating a strong spark for starting.
- **Considerations**
- Be aware of which magneto (left or right) is fitted with impulse coupling or induction vibrator, as this may vary by aircraft.
- Listen for an audible click when turning the propeller slowly on an engine with impulse coupling, indicating its operation.
- **Special Circumstances**
- If the engine is difficult to start, check if the impulse coupling or induction vibrator is functioning properly.
- If the aircraft uses a starter button instead of a key, understand the difference in starting procedure.

Spark Timing and Pre-Ignition

> Proper timing of the spark in relation to the piston's position is critical for engine efficiency and safety. The spark should occur just before the piston reaches top dead center (TDC), typically at 30 degrees before TDC. Incorrect timing can lead to advanced or retarded ignition, with potential for pre-ignition and engine damage.

- **Keypoints**
  - Spark should occur when the crankshaft is about 30 degrees before TDC.
  - Advanced timing: spark occurs earlier (e.g., 35 degrees before TDC).
  - Retarded timing: spark occurs later (e.g., 10 or 5 degrees before TDC).
  - If the spark is too late, burning gases may be ejected, causing overheating, especially of the exhaust valve.
  - Pre-ignition occurs when the mixture ignites before the spark fires, often due to residual heat or incorrect timing.
- **Explanation**
  The timing of the spark is set so that combustion pressure peaks at the optimal point in the piston's travel. If the spark is advanced, combustion starts too early, potentially causing knocking. If retarded, combustion is incomplete, leading to loss of power and overheating. Pre-ignition is a dangerous condition where the mixture ignites prematurely, often due to hot spots in the cylinder.
- **Considerations**
- Ensure spark timing is correctly set during maintenance and pre-flight checks.
- Understand the symptoms and risks of pre-ignition and advanced/retarded timing.
- **Special Circumstances**
- If pre-ignition is suspected (e.g., engine knocking, overheating), reduce power and land as soon as practical for inspection.

Ignition System Checks and Malfunctions

> The ignition system's proper functioning is primarily checked during power checks, specifically by comparing the operation of the left and right magnetos when cruise power is set. Malfunctions can also be detected if, after turning the key to the off position, the engine continues to rotate, indicating a grounding or wiring issue.

- **Keypoints**
  - Mechanics are responsible for checking wires and spark plugs for oil deposits and other issues.
  - Pilots can only check ignition system function during power checks and when shutting down the engine.
  - If the engine continues running after the key is turned off, grounding is not working.
  - On some aircraft, such as the cruiser, physical access to the engine is restricted.
- **Explanation**
  During pre-flight or routine checks, pilots set cruise power and check the response of both magnetos. If a malfunction is suspected, further mechanical inspection is

required. If the engine does not stop when the ignition is turned off, the mixture should be cut off (on Cessna) or mechanics should be notified (on cruiser).

- **Examples**
  > When the key is turned to the off position and the engine continues to rotate, it indicates a grounding or wiring issue.

  - Pilot attempts to shut down engine using ignition key.
  - Engine continues running, suggesting grounding failure.
  - On Cessna: cut off mixture to stop engine.
  - On cruiser: notify mechanics as mixture cut-off may not be possible.
- **Considerations**
- Always perform power checks to verify both magnetos.
- Do not attempt to open engine cowling on aircraft where it is not permitted.
- **Special Circumstances**
- If the engine does not stop after turning off the ignition, cut off the mixture (if possible) or notify mechanics.

FADEC (Full Authority Digital Engine Control) System

> FADEC is a computer or set of computers that controls air, fuel, and sometimes ignition timing in modern jet and general aviation aircraft. It automates engine management, including propeller pitch, mixture, and ignition, requiring only power setting input from the pilot.

- **Keypoints**
  - FADEC is standard on modern jets (Boeing, Airbus, Embraer, Bombardier) and newer general aviation aircraft (Diamond, new Cessnas, new Teclas).
  - FADEC can control propeller pitch automatically.
  - Replaces manual controls for magneto ignition, mixture, and sometimes propeller pitch.
  - Aircraft typically have two FADEC units (A and standby B) for redundancy.
  - FADEC relies on aircraft electrical power; if electrical system fails, FADEC and engine will stop unless emergency battery is available.
  - Emergency battery may provide approximately 30 minutes of power.
- **Explanation**
  FADEC simplifies engine management for pilots but introduces reliance on electrical systems. In case of total electrical failure, the emergency battery provides limited operation time (about 30 minutes). After battery depletion, engine stops as FADEC cannot control ignition or mixture.
- **Examples**

> If the aircraft loses all electrical power, the emergency battery can power FADEC, avionics, and lights for about 30 minutes. After that, the engine will stop.

  - Electrical system fails; FADEC switches to emergency battery.
  - Pilot must be aware of the 30-minute time limit.
  - After 30 minutes, engine stops due to loss of FADEC control.
- **Considerations**
- Monitor electrical system health in FADEC-equipped aircraft.
- Be aware of emergency battery duration (30 minutes).
- **Special Circumstances**
- If total electrical failure occurs, land within 30 minutes before emergency battery is depleted.

Diesel vs Petrol/Avgas Engines

> Diesel engines differ from petrol/avgas engines in that fuel is ignited by compression rather than a spark plug. Diesel engines often feature turbocharging, FADEC, single-power lever control, and liquid cooling, offering better fuel economy and requiring differences training for pilots.

- **Keypoints**
  - Diesel engines do not require spark plugs; ignition is by compression.
  - Diesel engines may include turbocharging, FADEC, and liquid cooling.
  - Better fuel economy compared to petrol/avgas engines.
  - Pilots must receive differences training when converting between engine types.
- **Explanation**
  When transitioning between diesel and petrol/avgas engines, pilots must understand operational differences, especially regarding ignition and engine management systems.
- **Considerations**
- Ensure proper training before operating a different engine type.

Magneto Impulse Coupling

> Magneto impulse coupling aids engine starting when the engine is turning over slowly by using a spring mechanism to induce a stronger spark.

- **Keypoints**
  - Impulse coupling is key when engine is rotating slowly.
  - A spring mechanism is wound up to aid starting.

- **Explanation**
  During engine start, the impulse coupling ensures sufficient spark energy for ignition at low RPM.

Faulty Magneto Outcomes and Power Checks

> A faulty magneto may allow the engine to continue running even when the ignition is turned off. Power checks are used to verify correct operation of both magnetos.

- **Keypoints**
  - During power checks, pilots verify both magnetos are operating.
  - A faulty magneto may result in the engine running when it should be off.
- **Explanation**
  Pilots perform power checks by switching between magnetos and observing engine response. Any abnormality indicates a malfunction.

Effects of Low RPM Operation on Spark Plugs

> Operating an air engine at low RPM for extended periods (20-30 minutes) can lead to oily or black deposits on spark plugs, causing damage.

- **Keypoints**
  - Idle operation for 20-30 minutes can cause spark plug fouling.
  - Deposits can damage spark plugs.
- **Explanation**
  To avoid fouling, avoid prolonged idle operation; shut down engine if extended ground time is expected.
- **Considerations**
- Turn off engine if prolonged ground time is expected.

Aircraft Cooling Systems: Air-Cooled, Liquid-Cooled, and Combined

> Modern piston aircraft engines are mostly air-cooled, but some (like the cruiser) use both liquid and air cooling. Cooling system design includes cowling, inlets, baffles, and cowl flaps to direct airflow and dissipate heat.

- **Keypoints**
  - Cowling covers the engine; inlets allow air entry.
  - Baffles and plates direct airflow over hottest engine parts.
  - Fins on cylinders increase surface area for heat dissipation.
  - Cowl flaps can be opened or closed to regulate cooling airflow.
  - Cruiser aircraft have both liquid and air cooling; cowl flaps are not adjustable.

- **Explanation**
  Air enters through inlets, is directed by baffles, and exits through gaps or cowl flaps. In liquid-cooled engines, increasing power increases coolant flow and cooling efficiency.
- **Considerations**
- Check that air inlets are clear during pre-flight.
- Do not attempt to adjust cowl flaps on aircraft where not permitted.

Cowl Flaps: Function and Operation

> Cowl flaps are adjustable openings in the engine cowling that regulate airflow for engine cooling. They are typically opened during ground operations, takeoff, and landing, and closed during cruise.

- **Keypoints**
  - Opening cowl flaps increases cooling airflow and drag.
  - Closed during cruise when less cooling is needed.
  - Manually controlled from cockpit in most aircraft.
- **Explanation**
  Pilots open cowl flaps when maximum cooling is required (ground, takeoff, landing) and close them in cruise to reduce drag.
- **Considerations**
- Adjust cowl flaps as required for phase of flight.

Axymetric Inlets and Cooling Drag

> Axymetric inlets are a modern design feature that improves cooling airflow and reduces drag compared to traditional cowl flaps. They are increasingly used in new aircraft.

- **Keypoints**
  - Axymetric inlets are located in the front cowling.
  - Reduce drag and may increase cruise speed (e.g., from 165 to 180 knots).
  - Used in modern aircraft like TechNum 2008.
- **Explanation**
  Axymetric inlets provide efficient cooling without the drag penalty of open cowl flaps.

Shock Cooling: Causes, Effects, and Prevention

> Shock cooling occurs when engine temperature drops too rapidly, especially in air-cooled engines. Lycoming recommends a maximum temperature drop of 50°F or 10°C per minute to avoid damage.

- **Keypoints**
  - Rapid cooling can occur after hard engine work followed by throttle closure and increased airspeed (e.g., nose dive).
  - Can cause worn rings, broken rings, bent push rods, and spark plug fouling.
  - Prevent by avoiding idle descents and using carburetor heat.
- **Explanation**
  During descent, maintain power above idle and monitor cylinder head temperature (CHT) to prevent rapid cooling.
- **Considerations**
- Monitor CHT during descent.
- Avoid idle power descents.

Cylinder Head Temperature (CHT) Monitoring

> CHT gauges measure temperature within the cylinder head. Aircraft manuals specify maximum CHT to prevent shock cooling and engine damage.

- **Keypoints**
  - Monitor CHT during descent and high-power operations.
  - Do not allow CHT to drop too quickly.
- **Explanation**
  Use CHT gauge to ensure temperature changes remain within manufacturer limits.

Pre-flight Inspection of Cooling System

> Pre-flight inspection includes checking that air inlets are clear and baffles are in good condition. Covers may be used to prevent birds or insects from entering.

- **Keypoints**
  - Check for blockages in air inlets.
  - Inspect baffles for security and condition.
  - On some aircraft, access to engine compartment is restricted.
- **Explanation**
  Ensure cooling system components are unobstructed and functional before flight.
- **Considerations**
- Remove covers from inlets before flight.
- Check only accessible components if engine compartment is locked.

Oil System: Wet Sump and Dry Sump

> Oil systems lubricate, cool, clean, seal, and protect engine parts. Wet sump systems store oil in a sump at the bottom of the crankcase; dry sump systems use a

> separate oil reservoir and scavenge pump.

- **Keypoints**
  - Wet sump: oil stored in sump below crankcase.
  - Dry sump: oil pumped to separate reservoir by scavenge pump.
  - Oil cooler dissipates heat from oil.
  - Pressure relief valve regulates oil pressure.
  - Oil returns to sump or reservoir by gravity.
- **Explanation**
  Oil is circulated by pump, cooled, and returned to reservoir. Wet sump is simpler; dry sump is used in high-performance engines.

Oil Pressure Checks and Timing Requirements

> After engine start, oil pressure must reach the green arc within a specified time. In general operations, this is 30 seconds; in plant-bite operations, 10 seconds.

- **Keypoints**
  - Monitor oil pressure after engine start.
  - If oil pressure is not in green arc within 30 seconds (general) or 10 seconds (plant-bite), shut down engine.
- **Explanation**
  Start engine, monitor oil pressure, and be prepared to shut down if pressure does not rise promptly.
- **Considerations**
- Know the required oil pressure timing for your operation.
- **Special Circumstances**
- If oil pressure does not reach green arc within 10 seconds (plant-bite) or 30 seconds (general), shut down engine.

Oil System Monitoring and Maintenance

> The oil system in aircraft engines requires regular monitoring and maintenance to ensure engine health and performance. This includes checking oil temperature and pressure, analyzing oil for debris, and following manufacturer guidelines for oil type and change intervals.

- **Keypoints**
  - Oil filters capture debris and should be cleaned or changed during routine servicing.
  - Shiny specks or shavings in the filter indicate possible engine wear due to friction.
  - Spectrographic oil analysis can detect engine wear at an early stage.

    - Oil temperature and pressure gauges are standard cockpit instruments.
    - Low oil pressure and low oil temperature are serious engine problems requiring urgent attention.
    - Use only the oil types specified in the POH and FM; car oil is not suitable for aircraft engines.
    - After major engine maintenance, straight mineral oil is used for the first 50 hours to allow components to wear in.
    - Oil viscosity is measured using the CAE system, and the correct grade depends on average air temperature.
    - Mixing oil grades of the same type is permissible if conditions require it.
    - High viscosity oil in cold conditions can become waxy and require preheating.
- **Explanation**
  During the lecture, the instructor emphasized the importance of monitoring oil system parameters and following correct procedures for oil maintenance. The oil filter should be checked for debris, and spectrographic analysis can provide early warning of engine wear. The correct oil type and grade must be used as specified in the aircraft's documentation. After major maintenance, straight mineral oil is used for break-in. Oil viscosity affects flow and pressure, especially in varying temperatures.
- **Examples**
  > The instructor mentioned that for a fleet of 42 aircraft, each requiring approximately 10 liters of oil, the total oil needed would be 420 liters.

    - The instructor calculated the oil requirement by multiplying the number of aircraft (42) by the oil needed per engine (10 liters), resulting in 420 liters.

  > To check the oil level, open the compartment, remove the cap and dipstick, crank the propeller by hand until a bulping sound is heard (indicating oil circulation), clean and reinsert the dipstick, and read the oil level. If below minimum, call mechanics.

    - The instructor described the step-by-step process for safely checking oil level, including the importance of circulating oil before measurement.
- **Considerations**
- Always use the oil type and grade specified in the POH and FM.
- Do not use car oil in aircraft engines.
- After major maintenance, use straight mineral oil for the first 50 hours.
- Check oil level only after circulating oil by cranking the propeller.
- In cold conditions, preheat the engine if oil is too viscous.
- **Special Circumstances**
- If shiny metal particles are found in the oil filter, investigate for possible engine wear.
- If oil pressure and temperature are both low, treat as a serious engine problem and land at the nearest airfield.

- If oil is below minimum on the dipstick, call mechanics for servicing.
- If oil becomes waxy in cold conditions, preheat the engine before starting.

Oil Viscosity and Temperature Effects

> Oil viscosity determines how easily oil flows and is affected by temperature. High viscosity means thick, slow-flowing oil; low viscosity means thin, fast-flowing oil. As engine temperature increases, oil viscosity decreases, leading to lower oil pressure.

- **Keypoints**
  - Viscosity is measured using the CAE system.
  - High viscosity oil flows less readily (like honey or Nutella).
  - Low viscosity oil flows more readily (like water).
  - As engine warms, oil viscosity and pressure decrease.
  - Correct oil grade depends on average air temperature.
- **Explanation**
  The instructor explained that viscosity is a measure of a fluid’s resistance to flow. High viscosity oils are thick and flow slowly, while low viscosity oils are thin and flow quickly. Temperature affects viscosity: as oil heats up, it becomes less viscous and oil pressure drops. The correct oil grade must be chosen based on expected temperature ranges.
- **Examples**
  > The instructor compared high viscosity oil to honey or Nutella and low viscosity oil to water, illustrating how temperature changes affect oil flow and pressure.

  - As the engine warms up, oil becomes less viscous, leading to a drop in oil pressure.
- **Considerations**
- Choose oil grade based on expected temperature range.
- Monitor oil pressure as engine warms up to ensure it remains within limits.
- **Special Circumstances**
- If oil is too viscous in cold weather, preheat the engine before starting.

Cockpit Instrumentation and Troubleshooting

> Aircraft cockpits are equipped with oil temperature and pressure gauges to monitor engine health. Pilots must interpret these readings correctly and respond to abnormal indications according to procedures.

- **Keypoints**
  - Oil temperature and pressure gauges are standard in the cockpit.
  - The POH specifies permissible temperature and pressure ranges.

- Low oil pressure and temperature are urgent issues.
    - Analog instruments may require tapping to restore readings.
    - Quiz questions test knowledge of oil system components and troubleshooting.
- **Explanation**
  The instructor discussed the importance of cockpit instrumentation for monitoring oil system health. Pilots must be able to interpret gauge readings and know when to take action, such as landing at the nearest airfield if a serious engine problem is indicated. Analog gauges may sometimes stick and require tapping.
- **Examples**
  > The instructor described a situation where the oil pressure or temperature gauge read zero, but tapping the instrument restored the reading. This is common with older, analog instruments.

    - Pilots should be aware that instrument readings may sometimes be incorrect due to mechanical issues and should verify before taking drastic action.
- **Considerations**
- Always verify abnormal instrument readings before taking emergency action.
- Know the permissible ranges for oil temperature and pressure as specified in the POH.
- **Special Circumstances**
- If both oil temperature and pressure are low, treat as a serious engine problem and land at the nearest airfield.
- If an analog gauge reads zero, tap the instrument to check if the reading returns before assuming a failure.

Simulator Use and Engine Control Demonstration

> Flight simulators can be used to practice engine control procedures, including mixture adjustment and magneto checks. Changes in RPM can be observed as mixture is leaned or magnetos are switched.

- **Keypoints**
    - Simulator practice is recommended before flight training.
    - RPM changes with mixture adjustment and magneto switching.
    - Ground checks require observing RPM drop within limits.
    - Cessna 172 engine shutdown is performed by pulling the mixture control.
- **Explanation**
  The instructor demonstrated engine control using a simulator, showing how RPM changes when adjusting mixture and switching magnetos. This helps students understand engine behavior and prepares them for real-world checks.
- **Examples**

> Increasing power to 2,100 RPM, then leaning the mixture causes RPM to decrease. Pulling the mixture fully stops the engine, as there is no more fuel.

- This demonstrates the effect of mixture on engine performance and the correct shutdown procedure for a Cessna 172.

> Switching between left, right, and both magnetos causes RPM to drop and rise within specified limits during ground checks.

- This procedure ensures both magnetos are functioning correctly before flight.

- **Considerations**
- Practice engine control procedures in a simulator before actual flight.
- Observe RPM changes during ground checks to verify magneto operation.
- **Special Circumstances**
- If RPM drop is outside limits during magneto check, do not fly and have the engine inspected.

Altimeter Subscale (QNH) Setting

> The altimeter subscale (QNH) must be set correctly to ensure accurate altitude readings. Incorrect settings can lead to altitude errors, which may affect flight safety.

- **Keypoints**
  - Altimeter shows elevation based on ambient pressure setting (QNH).
  - Increasing subscale increases indicated altitude; decreasing subscale decreases indicated altitude.
  - Incorrect QNH setting leads to incorrect altitude indication.
  - Setting QNH lower than actual causes indicated altitude to be higher than actual.
- **Explanation**
  The instructor explained how the altimeter subscale works and demonstrated the effect of changing the QNH setting. Students were told that incorrect settings could lead to significant altitude errors.
- **Examples**

  > If actual QNH is 1010 but set to 1005, the indicated altitude will be higher than the true altitude.

  - This can lead to safety issues, especially during approach and landing.
- **Considerations**
- Always set the correct QNH before flight.
- Understand how changes in QNH affect indicated altitude.
- **Special Circumstances**
- If unsure of the correct QNH, obtain it from ATIS or air traffic control before takeoff.

Aircraft Structural Elements

> Aircraft structures are composed of various elements including monocoque, semi-monocoque, stringers, ribs, spars, and frames. Each has a specific function in providing strength, shape, and support to the aircraft.

- **Keypoints**
  - Monocoque: structure where the skin supports most of the load.
  - Semi-monocoque: uses frames and stringers with a supporting skin.
  - Stringers: provide longitudinal strength.
  - Ribs: give the wing its profile shape.
  - Spars: take up vertical bending moments.
  - Frames: provide cross-sectional shape and support.
- **Explanation**
  The lecture discussed the differences between monocoque and semi-monocoque structures, emphasizing the role of stringers, ribs, and spars. The semi-monocoque structure is common in modern aircraft, using a combination of frames and stringers covered by a stressed skin, usually aluminum.
- **Examples**
  > Scratches on the tail are most likely due to a tail strike, which occurs when the tail contacts the ground during takeoff or landing.

  - The instructor asked what might cause scratches on the tail.
  - The answer is a ground strike, specifically a tail strike.
  - Other options like erosion or rotor blade contact were ruled out.
- **Considerations**
- Always identify the structural element responsible for a given function (e.g., ribs for shape, spars for bending).
- Understand the difference between monocoque and semi-monocoque structures.
- **Special Circumstances**
- If encountering unexplained scratches on the tail, check for evidence of a tail strike during ground operations.

Load Factor and Maneuvering

> Load factor on an airplane increases during steep level turns, requiring the pilot to pull up to maintain lift. Excessive load can result from abrupt maneuvers or heavy gusts.

- **Keypoints**
  - Steep level turns increase load factor.
  - Pilots must pull up during turns to avoid losing lift.

    - Exceeding maneuvering speed or encountering heavy gusts can cause excessive load.
- **Explanation**
  The instructor explained that during steep level turns, the load factor increases, and pilots must pull up to maintain altitude. Red Bull pilots were used as an example, showing the need to pull during rolls to avoid pitching down.
- **Examples**
  > Red Bull pilots must pull up during rolls to maintain level flight and avoid losing lift.

    - During races, pilots roll the aircraft and must pull to avoid pitching down.
    - This demonstrates the increased load factor during steep turns.
- **Considerations**
- Always perform smooth, not abrupt, maneuvers to avoid excessive load.
- Be aware of maneuvering speed limits.
- **Special Circumstances**
- If encountering turbulence, reduce airspeed to maneuvering speed to minimize risk of structural overload.

Wing Construction and Function

> Wings are constructed using skin, ribs, spars, and stringers. Ribs define the wing's profile shape, spars handle vertical bending, and stringers resist twisting.

- **Keypoints**
    - Ribs give the wing its profile shape.
    - Spars take up vertical bending moments.
    - Stringers resist twisting forces.
- **Explanation**
  The instructor used diagrams and questions to reinforce the identification of wing components and their functions. Ribs were identified as the element giving the wing its shape, while spars and stringers handle different structural loads.
- **Examples**
  > Students were asked to identify which elements take up vertical bending (spars) and which resist twisting (stringers).

    - Spars are the long metal elements running spanwise.
    - Stringers run longitudinally and prevent twisting.
- **Considerations**
- Correctly identify wing elements in diagrams and real aircraft.
- Understand the specific function of each structural element.
- **Special Circumstances**

- If a wing exhibits unexpected twisting, inspect stringers for damage or failure.

Composite and Sandwich Structures

> Composite structures use thin layers and light forms (such as honeycomb) to achieve high stiffness, strength, and stability at low weight. Sandwich structures are not easily formable and resist twisting.

- **Keypoints**
  - Composite structures consist of thin layers and light core materials.
  - Sandwich structures provide high stiffness and strength.
  - Honeycomb core is common in sandwich structures.
- **Explanation**
  The instructor clarified that sandwich structures are not formable and have high tension force. Honeycomb structures are used for their strength and stiffness.
- **Examples**
  > Students identified low weight, high stiffness, high stability, and high strength as advantages of sandwich structures.

  - Sandwich structures are used where high performance and low weight are required.
- **Considerations**
- Do not attempt to form sandwich structures; they are not designed for shaping after manufacture.
- **Special Circumstances**
- If a sandwich structure is damaged, replacement is often required rather than repair.

Landing Gear Types and Operation

> Landing gear can be operated hydraulically or electrically. Types include wheels, skis, and floats. Creep marks on tires indicate alignment between rim and tire. Brakes are installed only on the main gear.

- **Keypoints**
  - Landing gear operation: hydraulic or electric.
  - Types: wheels, skis, floats.
  - Creep marks show rim-to-tire alignment.
  - Brakes are only on main gear.
- **Explanation**
  The instructor discussed landing gear operation, types, and maintenance checks. Creep marks are used to ensure the tire does not rotate independently of the rim.
- **Examples**
  > Creep marks are checked to ensure the tire and rim rotate together.

    - If creep marks are misaligned, the tire may be slipping on the rim.
- **Considerations**
- Always check creep marks during preflight inspections.
- Know the location of brakes (main gear only).
- **Special Circumstances**
- If creep marks are misaligned, inspect for tire slippage and correct before flight.

Shock Absorbers and Oleo Struts

> Oleo struts use nitrogen and oil to absorb landing shocks. Oil provides damping, while nitrogen acts as a spring.

- **Keypoints**
    - Oil provides damping force.
    - Nitrogen acts as a spring.
    - Oleo struts are common in landing gear.
- **Explanation**
  The instructor explained the function of oil and nitrogen in oleo struts, emphasizing their roles in absorbing and damping landing forces.
- **Examples**
  > Students identified oil as the damping medium and nitrogen as the spring force in shock absorbers.

    - Proper function of both components is essential for safe landings.
- **Considerations**
- Check for visible oleo extension during preflight.
- Low oleo extension may indicate low pressure.
- **Special Circumstances**
- If no oleo extension is visible, check for low pressure or maintenance issues.

Aircraft Sound and Airframe Components

> Aircraft sound is composed of various sources, and airframe includes fuselage, wings, stabilizers, control surfaces, powerplant, and landing gear.

- **Keypoints**
    - Airframe includes fuselage, wings, stabilizers, control surfaces, powerplant, landing gear.
    - Fuselage is the main body of the aircraft.
- **Explanation**
  The instructor clarified the definitions of airframe and fuselage, and discussed the components that make up the aircraft's sound.

- **Examples**
  > Students were asked to identify all components included in the airframe.

  - Airframe is more than just the fuselage; it includes all major structural elements.
- **Considerations**
- Understand the distinction between airframe and fuselage.

Assignments & Suggestions

- Watch the recommended YouTube channel for further explanations on aircraft systems, including flight controls, engine, landing gear, fuel system, oil system, hydraulic, and electrical systems.
- Save your email and password for system access and keep the email for reference.
- Watch the recommended video on the ignition system from the specified channel for further understanding.
- Underline or take screenshots of key points in the provided materials for study.