2025-05-12 - POF Lecture 1

> Date & Time: 2025-05-12 15:28:33
> Location: [Insert Location]
> [Insert Title]
> `Flight Instruments` `Airspeed Concepts` `Gyroscopic Principles`

Theme

Takeaways

1. Discussion regarding student attendance for class 1, as some students were noted as missing.
2. Confirmation of current academic progress: students are in Lesson 14, on page 253.
3. Inquiry made about the total number of slides for “western 16” (presumably a lesson or module).
4. Clarification that progress tests are normally conducted in class.
5. Typical break schedule during lectures consists of two or three breaks, duration and timing depend on lecture length or after each chapter.
6. Some students reported having prior flight experience, specifically 10 hours of PPL (Private Pilot License) with instruction, obtained in Ireland and France.
7. The current new batch of students started their course on either last Monday (2025-05-05) or last Tuesday (2025-05-06).
8. Students generally find the course difficulty to be “ok” so far.
9. The next topic or lesson to be covered is “12”, scheduled to start on 2025-05-13.
10. Discussion on the benefits of blue light filtering glasses for reducing eye strain during extended reading, with a specific mention of a 0.25 prescription.

Highlights

- `"this is a very important concept for everything in aviation okay this is how we measure speed this is how a wing produces lift for the aircraft to fly. this is how a carburetor works this is everything in aviation okay so it's very important to understand this concept all right"-- Lecturer 《Lecture on flight instruments》`
- `"In aviation, there's always... if something is critical there's always a redundancy."-- Lecturer 《The lecture》`

- `"For handling purposes, for flying, right, we care about the indicated airspeed because it's the one that measures dynamic pressure."-- Lecturer`
- `"If you understand how the thing works, it's really easy to actually know what's happening."-- Lecturer`
- `"If you actually have to memorize a bunch of mnemonics for every single subject, you're going to end up hating your ATPL, okay?"-- Lecturer`
- `"Step on the ball."-- The lecturer 《Common flying rule mentioned in the lecture.》`
- `"Is the earth going to suddenly lose its magnetic field? Probably not. So it's very hard that it fails, okay?"-- lecturer 《Lecture on aircraft instruments》`

Chapters & Topics

Aircraft Main Instrument Panel: The 6-Pack Configuration

> Introduction to the main instrument panel commonly found in aircraft that students will be flying. This standard configuration is known as the '6-pack' and comprises six different flight instruments. The instructor noted that this was the students' first time seeing these instruments.

- **Keypoints**
  - The aircraft instrument panel configuration discussed is commonly referred to as the '6-pack'.
  - This '6-pack' consists of 6 distinct flight instruments.
  - It is possible to fly the aircraft using only 4 of these 6 instruments.
  - Students are expected to learn to identify these 4 fundamental (essential) instruments.
- **Explanation**
  The instructor clarified that while the '6-pack' includes six instruments, pilots can effectively operate the aircraft using only four of these. Students were prompted to consider which instruments are fundamental, as not all six are essential for basic flight. The instructor emphasized the importance of identifying these 'truly fundamental ones'. (Original Estonian context: 'Nüüd, sa võib tegelikult tööma ainult 4 korda…Sa võib tööma ainult tõepõhimõtteliselt korda, mida me kallame. Okei? Mis korda sa arvad, et see on väga tõepõhimõtteliselt?')

Pitot-Static System for Airspeed Measurement

> The system used in aircraft to measure airspeed, consisting of a pitot tube and static port(s), which provide differential pressure readings to the airspeed indicator.

- **Keypoints**
  - Pitot tube measures total pressure (dynamic + static).
  - Static port measures ambient static pressure.
  - Airspeed is derived from dynamic pressure.
  - Dynamic pressure = Total pressure - Static pressure.
  - The pitot tube is connected to the airspeed indicator.
  - The static port is connected to the airspeed indicator, altimeter, and vertical speed indicator (VSI).
- **Explanation**
  The pitot tube, facing the airflow, captures total pressure (the sum of static pressure and dynamic pressure). Static ports, usually on the fuselage sides, measure the ambient static pressure. The airspeed indicator receives both total pressure from the pitot tube and static pressure from the static port. It then mechanically or electronically subtracts the static pressure from the total pressure. The result is dynamic pressure, which is directly proportional to the square of the airspeed. This dynamic pressure is then calibrated and displayed as airspeed on the instrument.
- **Considerations**
- Pitot tube can become blocked by ice; pitot heat is essential in icing conditions.
- Insects or dirt can obstruct the pitot tube when the aircraft is on the ground; covers should be used, and a thorough pre-flight inspection is critical.
- Never blow into a pitot tube, as this can damage the sensitive internal mechanisms of the instruments.
- Static ports can also be affected by blockages or damage, leading to erroneous readings on all pitot-static instruments.
- Alternate static sources may be available in case of primary static port blockage, but they may have their own inaccuracies.
- A blocked pitot tube will cause the airspeed indicator to behave like an altimeter if the drain hole is also blocked (airspeed increases in climb, decreases in descent).
- A blocked static port will cause the airspeed indicator to read inaccurately (under-read in climb, over-read in descent if pitot is clear), the altimeter to freeze at the altitude where blockage occurred, and the VSI to read zero.
- **Special Circumstances**
- If encountering icing conditions, how should it be addressed? Activate the pitot heat system.
- If an insect nest is suspected or found in a pitot tube during pre-flight, how should it be addressed? The blockage must be carefully removed by qualified personnel before flight. Flying with a known or suspected blockage is dangerous.
- If the static port is blocked, how will it affect the airspeed indicator? The airspeed indicator will under-read as the aircraft climbs and over-read as it descends,

because it's using trapped static pressure from a lower/higher altitude respectively against the varying total pressure from the pitot tube.

Barometric Altimeter Operation

> The barometric altimeter is an instrument that measures an aircraft's altitude above a selected pressure level by sensing changes in atmospheric pressure.

- **Keypoints**
  - Measures altitude based on atmospheric pressure changes.
  - Core component is the aneroid capsule (or stack of capsules).
  - Instrument casing is connected to the static port.
  - Aneroid capsules expand with decreasing pressure (increasing altitude) and contract with increasing pressure (decreasing altitude).
  - Mechanical linkage translates capsule movement to altitude indication on the dial.
  - Requires a correct reference pressure setting (e.g., QNH, Standard) for accurate readings relevant to the phase of flight.
  - Calibrated according to a standard atmosphere pressure lapse rate (approx. 1 hPa per 27 feet near sea level in ISA).
- **Explanation**
  The altimeter contains a stack of sealed aneroid capsules (thin, corrugated metal discs with most of the air evacuated). These capsules are sensitive to changes in air pressure. The instrument case surrounding the aneroid capsules is vented to the static port, allowing it to sense the current ambient atmospheric pressure. As the aircraft ascends, the atmospheric pressure decreases, causing the aneroid capsules to expand. Conversely, as the aircraft descends, atmospheric pressure increases, causing the capsules to contract. This expansion and contraction is mechanically amplified by a system of levers and gears, which drive the pointers on the altimeter face to indicate altitude. Pilots can set a reference pressure on a subscale (Kollsman window); if QNH is set, it indicates altitude above mean sea level.
- **Examples**
  > An aircraft is on the ground at an airport with a field elevation of 500 feet. The current QNH is 1014 hPa, which the pilot sets on the altimeter.

  - With 1014 hPa (QNH) set, the altimeter on the ground will indicate the field elevation of 500 feet.
  - As the aircraft climbs, the static pressure fed to the altimeter casing decreases.
  - The pressure difference between the inside of the aneroid capsules (which are sealed and maintain their internal pressure characteristics relative to the setting) and the decreasing external static pressure causes the capsules to expand.

    - This expansion is mechanically translated into a rotation of the altimeter pointers, indicating an increase in altitude above mean sea level.
- **Considerations**
- It is crucial to have the correct altimeter setting for the phase of flight and location; incorrect settings can lead to significant errors in indicated altitude.
- Temperature variations from the standard atmosphere can cause altimeter errors (e.g., flying from warmer to colder air makes the altimeter over-read).
- Mechanical altimeters are subject to instrument error.
- A blocked static port will cause the altimeter to indicate the altitude at which the blockage occurred.
- **Special Circumstances**
- If flying from an area of high pressure to an area of low pressure without updating the QNH setting, how would this affect the indicated altitude? The altimeter will over-read, meaning the aircraft is lower than the altimeter indicates (‘High to Low, Look out Below’).
- If the altimeter setting is 1013 hPa (Standard) and the actual sea level pressure (QNH) is 1000 hPa, how does the indicated Flight Level relate to true altitude? The aircraft will be at a true altitude lower than the indicated Flight Level because the standard atmosphere assumes a higher pressure at sea level than actually exists.

Altimeter Settings (QNH, QFE, Standard)

> Different reference pressures that can be set on a barometric altimeter to provide various types of altitude or height information, essential for safe flight operations.

- **Keypoints**
    - QNH provides altitude above mean sea level (MSL).
    - QFE provides height above a specific reference point, typically an airfield.
    - Standard Setting (1013 hPa / 29.92 inHg) is used for Flight Levels above the transition altitude.
    - Correct altimeter setting is critical for vertical separation from other aircraft and terrain clearance.
    - Pilots must use QNH below the transition altitude and Standard Setting at or above the transition altitude (when climbing) or transition level (when descending).
    - Transition altitude in Spain is generally 6000 feet, with exceptions like Granada (7000 ft) and Madrid (13000 ft).
- **Explanation**
  QNH: This is the atmospheric pressure observed at an aerodrome, adjusted to mean sea level (MSL) assuming standard atmospheric conditions between the aerodrome and MSL. When QNH is set, the altimeter indicates altitude above MSL.

For example, on 2025-05-12, the QNH in Burgos was 1014 hPa. This is the primary setting for flights below the transition altitude.
QFE: This is the actual atmospheric pressure at a specific datum, usually an airfield elevation. When QFE is set, the altimeter indicates height above that specific datum. So, on the ground at that airfield, the altimeter would read zero. It is not commonly used in general aviation school flights but may be used by aerobatic pilots or gliders.
Standard Setting (1013 hPa or 29.92 inHg): This is a globally agreed-upon pressure setting based on the International Standard Atmosphere (ISA) pressure at MSL (1013.25 hPa, often rounded to 1013 hPa). When this is set, the altimeter indicates Pressure Altitude, which is referred to as a Flight Level (FL) when above the transition altitude (e.g., 18,000 feet pressure altitude is FL180). This ensures all aircraft operating above the transition altitude use a common vertical reference.

- **Examples**

  > A pilot in Burgos, where the QNH is 1014 hPa on 2025-05-12, sets this value on their altimeter.

  - The altimeter will now indicate the aircraft’s altitude above mean sea level.
  - If Burgos airport has an elevation of 2800 feet MSL, the altimeter should read 2800 feet while on the ground at the airport with 1014 hPa set.

  > An aircraft climbs through the transition altitude of 6000 feet in Spain.

  - Upon reaching 6000 feet, the pilot changes the altimeter setting from the local QNH to the Standard Setting of 1013 hPa.
  - The altitude is now referred to as a Flight Level. For example, if the altimeter indicates 10,000 feet, the aircraft is at Flight Level 100 (FL100).
- **Considerations**
- QNH values change with weather conditions and location, so pilots must obtain the current QNH for their area of operation.
- QFE is rarely used for general aviation school flights.
- The transition altitude (for changing from QNH to Standard when climbing) and transition level (for changing from Standard to QNH when descending) are published for specific regions/airports.
- **Special Circumstances**
- If the local QNH is 1000 hPa but the pilot is flying at a Flight Level using the Standard Setting of 1013 hPa, how will the aircraft’s true altitude compare to its indicated Flight Level? The aircraft’s true altitude will be lower than the indicated Flight Level because the ambient pressure decreases more rapidly with height than the standard atmosphere model used by the altimeter assumes for that setting.
- What is the procedure for altimeter settings when crossing the transition altitude? When climbing through the transition altitude, set the altimeter to Standard (1013 hPa). When descending through the transition level (which may be different from the transition altitude), set the altimeter to the local QNH.

Bernoulli’s Principle and Pressure Dynamics in Airflow

> A fundamental principle in fluid dynamics stating that for an inviscid, incompressible flow, an increase in the speed of the fluid occurs simultaneously with a decrease in static pressure or a decrease in the fluid’s potential energy. In aviation, it’s key to understanding lift, airspeed measurement, and carburetor function.

- **Keypoints**
  - Total pressure = Static pressure + Dynamic pressure.
  - In an incompressible, inviscid flow, total pressure remains constant along a streamline.
  - Increased fluid speed (hence increased dynamic pressure) leads to decreased static pressure.
  - Decreased fluid speed (hence decreased dynamic pressure) leads to increased static pressure.
  - This principle explains airflow behavior in convergent (narrowing) and divergent (widening) passages.
  - It is a foundational concept for understanding lift, airspeed indication, and carburetor operation in aviation.
- **Explanation**
  Bernoulli’s principle states that the total pressure along a streamline is constant. Total pressure is composed of static pressure (the ambient pressure of the fluid) and dynamic pressure (the pressure due to the fluid’s motion). Mathematically, for horizontal flow: Static Pressure + Dynamic Pressure = Constant. Dynamic pressure is proportional to the square of the fluid’s velocity.
  When air flows through a constriction (like a Venturi tube), it must accelerate to maintain the same volume flow rate (assuming incompressibility). This increase in speed means an increase in dynamic pressure. Since the total pressure must remain constant, the static pressure in the constricted section must decrease. Conversely, if the airflow passage widens, the air decelerates, dynamic pressure decreases, and static pressure increases.
  This principle is applied in:

1. Airspeed measurement: The pitot-static system measures total and static pressures; their difference gives dynamic pressure, from which airspeed is calculated.
2. Lift generation: Airfoils are designed so air flows faster over the curved upper surface than the flatter lower surface. This higher speed on top results in lower static pressure compared to the bottom surface, creating a net upward force (lift).
3. Carburetors: A Venturi in the carburetor throat accelerates air, reducing static pressure, which helps draw fuel into the airstream.

- **Examples**

> Air is flowing through a tube that narrows in its middle section (the Venturi throat) and then widens again.

  - In the initial wider section of the tube, the air has a certain velocity and static pressure.
  - As the air enters the narrower Venturi throat, its velocity increases due to the conservation of mass (it must speed up to pass the same amount of air through a smaller area).
  - This increase in velocity results in an increase in dynamic pressure.
  - According to Bernoulli's principle, because the total pressure must remain (approximately) constant, the static pressure in the Venturi throat must decrease.
  - As the air exits the throat and enters the diverging section, it slows down, its dynamic pressure decreases, and its static pressure increases again.
- **Considerations**
- The principle strictly applies to ideal fluids (inviscid, incompressible), but provides a very good approximation for air at subsonic speeds typical of general aviation.
- Understanding this relationship between pressure and speed is critical for pilots to grasp how flight instruments work and how aerodynamic forces are generated.
- **Special Circumstances**
- How does Bernoulli's principle relate to the operation of an airspeed indicator? The airspeed indicator uses the pressure difference between total pressure (from the pitot tube) and static pressure (from the static port). This pressure difference is the dynamic pressure, which Bernoulli's principle links directly to airspeed.
- How is this principle involved in ice formation in a carburetor? The drop in static pressure within the carburetor Venturi also causes a drop in temperature. If moisture is present in the air and the temperature drops below freezing, carburetor ice can form.

Vertical Speed Indicator (VSI): Operation and Utility

> The Vertical Speed Indicator (VSI), or variometer, measures the aircraft's rate of climb or descent, typically in feet per minute. It operates by sensing the rate of change of static pressure using a mechanism with an instantaneous and a delayed static pressure feed.

- **Keypoints**
  - Measures the rate of climb or descent (vertical speed).
  - Standard unit of measurement is feet per minute (ft/min).
  - A standard IFR climb/descent rate is often 500 ft/min.
  - Works by comparing an instantaneous static pressure reading with a delayed static pressure reading.

    - The delay is achieved by feeding static pressure into a chamber (the instrument case) through a constricted passage or calibrated leak.
    - An aneroid capsule inside the case receives instantaneous static pressure.
    - During a climb, case pressure is higher than capsule pressure (as capsule pressure drops faster), causing the capsule to contract.
    - During a descent, capsule pressure is higher than case pressure (as capsule pressure rises faster), causing the capsule to expand.
    - In level flight, pressures equalize, and the VSI reads zero.
    - The VSI is generally faster to indicate changes in vertical speed than deriving it from the altimeter alone.
    - Display can be an analog needle or a digital tape on a PFD/MFD.
    - Limit example: 6,000 feet per minute on some displays.
    - Calculation example: Climbing/descending at 500 feet per minute for 2 minutes results in a 1,000 feet altitude change.
- **Explanation**
  The VSI has a casing connected to the static pressure line via a calibrated leak (a narrow tube). Inside the casing, an aneroid capsule is also connected to the static pressure line, but more directly (instantaneously). When the aircraft climbs or descends, the pressure inside the capsule changes almost instantly, while the pressure inside the casing (outside the capsule) changes more slowly due to the calibrated leak. This creates a pressure differential across the capsule walls, causing the capsule to expand or contract. This movement is mechanically linked to a pointer that indicates the rate of climb or descent. When the aircraft is in level flight, the pressure inside and outside the capsule equalizes, and the VSI indicates zero.
- **Examples**

  > During a descent, the anaerobic capsule will increase the size… Why? Because when we descend, the pressure increases, right? So the pressure inside the capsule will be higher, right? The pressure inside the capsule will be higher than the pressure outside the capsule, right? The orange arrows will be stronger, will have more force, more pressure than the red arrows in this case. so the capture will have the tendency to expand.

    - When an aircraft descends, the ambient static pressure increases.
    - The pressure inside the VSI’s aneroid capsule (instant static pressure feed) increases rapidly.
    - The pressure inside the VSI case (delayed static pressure feed via calibrated leak) increases more slowly.
    - This results in a temporary state where the pressure inside the capsule is higher than the pressure in the surrounding case.
    - This higher internal pressure causes the aneroid capsule to expand, which is mechanically translated to an indication of descent on the VSI display.

- **Considerations**
- The VSI is a useful instrument, though not as critical as the altimeter for basic flight.
- It's very useful because the altimeter normally comes with a big time-lapse, and the VSI is normally faster in indicating the initiation of a climb or descent.
- With the VSI, as soon as you start a descent, you can normally check out at that moment by how many feet you're climbing or descending, while by looking just at the altimeter, it's slightly more difficult.
- There's no type of setting (like QNH) on the VSI itself; it measures rate of change of pressure directly.
- **Special Circumstances**
- Once the aircraft stabilizes in level flight (stops climbing or descending), the delayed static pressure in the VSI case equalizes with the instant static pressure in the capsule, and the VSI will read zero.
- The delay in the static pressure feed to the VSI case is achieved by making the connecting tube 'really small and tight', restricting airflow.

Vertical Speed Indicator (VSI) Operation and Errors

> The VSI indicates an aircraft's rate of climb or descent. It is fed by the static port and thus shares similar errors with the altimeter, such as instrument error, time lag, position error, and maneuver-induced error.

- **Keypoints**
  - VSI errors include instrument error (due to manufacturing), time lag, position error (due to static port location), and maneuver-induced error (due to side slip).
  - An instantaneous VSI uses an accelerometer to provide more immediate readings and reduce time lag.
  - A blocked static port will cause the VSI to read zero or cease functioning.
  - For BFR (Basic Flight Rules), an error of plus or minus 200 feet per minute in VSI reading can be acceptable.
  - The VSI is a helpful instrument, but rate of climb/descent can also be checked using an altimeter and a watch to time altitude changes.
- **Explanation**
  The VSI can be prone to time lag. To counter this, modern aircraft may use an instantaneous VSI, which incorporates an accelerometer measuring pitch axis acceleration to provide quicker indications of vertical speed changes. For example, if a pilot pitches up during a glide, an instantaneous VSI will show a positive vertical speed indication more rapidly than a conventional VSI. If the static port becomes blocked (e.g., by ice), the VSI will typically indicate zero or stop working. This topic will be covered in more depth in 'instruments in phase 2'.
- **Examples**

> If a pilot starts to glide and then pitches up, an instantaneous VSI, equipped with an accelerometer, will immediately start indicating a bit of a positive vertical speed.

  - The accelerometer detects the pitch-up maneuver based on acceleration along the pitch axis.
  - This allows the instrument to anticipate and display the change in vertical speed more quickly than a conventional VSI, which relies solely on barometric pressure changes that have inherent lag.
- **Special Circumstances**
- If the static port becomes blocked by ice or something like that, how should it be addressed? The VSI will stay at zero. It will just stop working.

Airspeed Indicator (ASI) Principles and Operation

> The Airspeed Indicator (ASI) measures airspeed, primarily by displaying Indicated Airspeed (IAS). IAS is a measure of dynamic pressure, derived from the difference between total pressure (from the pitot tube) and static pressure (from the static port).

- **Keypoints**
  - The ASI measures Indicated Airspeed (IAS), which is a representation of dynamic pressure.
  - It utilizes total pressure from the pitot tube and static pressure from the static port.
  - Dynamic pressure is the difference between total pressure and static pressure.
  - IAS is critical for aircraft handling and performance (e.g., stall speeds, flap operation speeds).
  - True Airspeed (TAS) is used for navigation calculations.
- **Explanation**
  The ASI is a sealed case containing a sensitive capsule. The pitot tube directs total pressure into this capsule, while the static port provides static pressure to the area outside the capsule within the sealed case. The difference between these two pressures is dynamic pressure. When the aircraft is stationary on the ground, there is no forward speed, so dynamic pressure is zero (total pressure equals static pressure), and the ASI reads zero. As the aircraft moves forward, dynamic pressure increases, causing the capsule to expand. This expansion is mechanically linked to a needle on the ASI display, which then indicates the airspeed. The faster the aircraft flies, the greater the dynamic pressure, and the higher the airspeed indication. It's crucial to understand that the ASI primarily measures dynamic pressure (indicated airspeed), which is vital for aircraft handling because aerodynamic forces like lift and drag are directly related to dynamic pressure. True Airspeed (TAS), the actual speed

of the aircraft through the air, is more relevant for navigation purposes (e.g., calculating flight time and fuel consumption).

ASI Color Coding and Associated V-Speeds

> The ASI dial features standardized color codings that delineate critical airspeed ranges for safe aircraft operation. These ranges are defined by various V-speeds (velocity speeds).

- **Keypoints**
  - White Arc: VSO (Stall Speed, landing configuration) to VFE (Maximum Flaps Extended speed).
  - Green Arc: VS1 (Stall Speed, specific configuration) to VNO (Maximum Normal Operating speed).
  - Yellow Arc: VNO to VNE (Never Exceed speed) - caution range, smooth air only.
  - Red Line: VNE (Never Exceed speed).
  - VSO: Stall speed with flaps fully deployed (landing configuration).
  - VFE: Maximum speed with flaps extended.
  - VS1: Stall speed in a specified configuration (e.g., takeoff flaps or clean).
  - VNO: Maximum structural cruising speed; exceed only with caution in smooth air.
  - VNE: Never exceed speed; flying beyond this can cause structural failure.
- **Explanation**
  The color arcs on the ASI are standard for all aircraft:

- **White Arc (Flap Operating Range):**Extends from VSO (Stall Speed in Landing Configuration - full flaps) to VFE (Maximum Flaps Extended Airspeed). Flaps should only be operated within this speed range.
- **Green Arc (Normal Operating Range):**Goes from VS1 (Stall Speed in a specific configuration, typically clean or takeoff flaps) to VNO (Maximum Normal Operating Speed or Maximum Structural Cruising Speed). Within this range, the aircraft can withstand full control deflections without structural damage, assuming smooth air.
- **Yellow Arc (Caution Range):**Starts from VNO and goes up to VNE. Flight in this range should be conducted with caution, in smooth air only, and aggressive maneuvers must be avoided as they could lead to structural damage.
- **Red Line (VNE):**Represents VNE (Never Exceed Speed). Flying at or beyond this speed can cause catastrophic structural failure. VNE is set at 90% of VD (Dive Speed), which is a speed at which control surface flutter and other dangerous aerodynamic effects can occur.

- **Considerations**

- Flight above VNO (into the yellow arc) should only be done with caution and in smooth air conditions.
- Avoid strong or abrupt maneuvers when flying in the yellow arc speed range.
- Exceeding VNE can lead to catastrophic structural failure of the aircraft.

Aircraft Stall Characteristics

> An aircraft stalls when the critical angle of attack of the wings is exceeded, leading to a loss of lift. While stall speed is an important reference indicated on the ASI, a stall is fundamentally tied to angle of attack, not a specific airspeed in all conditions.

- **Keypoints**
  - An aircraft stalls when its critical angle of attack is exceeded.
  - A stall can occur at any airspeed if the critical angle of attack is surpassed.
  - Indicated stall speed (VSO, VS1) is a reference for specific configurations and level flight, but the aircraft always stalls due to exceeding the critical angle of attack.
  - For general aviation practical purposes, indicated stall speed is often treated as constant with altitude/temperature, but this is a simplification.
- **Explanation**
  For practical purposes in general aviation, the aircraft is often said to stall at the same indicated airspeed irrespective of altitude or temperature. However, this is an approximation and not entirely accurate, especially at very high altitudes where TAS significantly diverges from IAS. The primary cause of an aerodynamic stall is always exceeding the wing's critical angle of attack. An aircraft can be stalled at any airspeed if the critical angle of attack is exceeded, for instance, during aggressive maneuvers or by pitching up too steeply. The stall speeds marked on the ASI (like VSO and VS1) are reference speeds for specific aircraft configurations (e.g., flaps deployed, clean configuration, specific weight) and 1G flight.

Four Types of Airspeed

> In aviation, airspeed is categorized into four main types: Indicated Airspeed (IAS), Calibrated Airspeed (CAS), Equivalent Airspeed (EAS), and True Airspeed (TAS). Each serves different purposes in understanding aircraft performance and navigation.

- **Keypoints**
  - Indicated Airspeed (IAS): Read directly from the ASI; uncorrected.
  - Calibrated Airspeed (CAS): IAS corrected for instrument and position (installation) errors.
  - Equivalent Airspeed (EAS): CAS corrected for compressibility effects (more relevant at high speeds/altitudes).

    - True Airspeed (TAS): CAS/EAS corrected for non-standard air density; represents the aircraft's actual speed through the air.
- **Explanation**
    i. **Indicated Airspeed (IAS):**This is the airspeed read directly from the aircraft's airspeed indicator. It is uncorrected for instrument or installation errors.

2. **Calibrated Airspeed (CAS):**IAS corrected for instrument errors and position (installation) error. The position error arises from the actual location of the pitot tube and static port(s) on the aircraft, which may not always sense undisturbed airflow. CAS is a more accurate measure of the dynamic pressure acting on the aircraft than IAS. It is sometimes referred to as Rectified Airspeed (RAS), though CAS is the more common term.
3. **Equivalent Airspeed (EAS):**CAS corrected for compressibility effects, which become significant at high airspeeds (typically above 200 knots) and high altitudes. (The lecture mentions EAS as one of the four types but does not elaborate further in this segment).
4. **True Airspeed (TAS):**CAS (or EAS at higher speeds) corrected for air density variations from standard sea-level conditions. Air density changes with altitude and temperature. TAS is the actual speed of the aircraft through the air mass and is crucial for flight planning and navigation.

- **Examples**
    > A Pilot Operating Handbook (POH) or Aircraft Flight Manual (AFM) often includes a table to convert IAS to CAS. This table accounts for the specific instrument and position errors measured for that aircraft type. For example, the table might show that at an IAS of 100 knots, the CAS is 102 knots, or at an IAS of 150 knots, the CAS is 148 knots. The lecturer noted that an example difference of 9 knots would be considered a large error.

    - The correction values in the POH/AFM are determined through flight testing by the manufacturer.
    - Pilots use this table to obtain a more accurate airspeed (CAS) for performance calculations and adherence to speed limitations.

Dynamic Pressure (Q) and Density Error

> Dynamic pressure (Q) is the kinetic energy per unit volume of a moving fluid (air, in this case) and is given by the formula $Q = 1/2 * \rho * V^2$, where ρ is air density and V is True Airspeed. The ASI is calibrated to ISA standard density, leading to 'density error' when actual conditions differ.

- **Keypoints**
    - Dynamic pressure formula: $Q = 1/2 * \rho * V^2$ (ρ = air density, V = True Airspeed).
    - ASI is calibrated for ISA standard air density: 1.225 kg/m^3 at mean sea level.

    - Density error arises when actual air density deviates from ISA standard, causing IAS to differ from TAS.
    - At a constant IAS, TAS increases as altitude increases (due to decreasing air density).
    - Commercial aircraft fly high to take advantage of lower air density, achieving higher TAS and better fuel efficiency.
    - Rule of thumb for TAS estimation: Increase IAS by about 2% per 1000 feet of altitude, or approximately 2 knots per 1000 feet for speeds around 90 knots.
- **Explanation**
  The formula for dynamic pressure is $Q = 1/2 * \rho * V^2$, where ‘ρ’ (rho) is the air density and ‘V’ is the True Airspeed (TAS). The airspeed indicator is calibrated to International Standard Atmosphere (ISA) conditions, specifically an air density of 1.225 kg/m^3 at mean sea level. When the actual air density differs from this standard value (e.g., at higher altitudes where density is lower, or due to non-standard temperatures), the Indicated Airspeed (IAS) will not be equal to the True Airspeed (TAS). This difference is known as density error.

Effect of Altitude: If an aircraft climbs while maintaining a constant IAS (which means constant dynamic pressure Q), and air density (ρ) decreases with altitude, then the True Airspeed (V in the formula) must increase to maintain that constant Q. Therefore, TAS is generally higher than IAS at altitudes above mean sea level (assuming standard or warmer than standard temperatures).

This principle is why commercial aircraft fly at high altitudes: the lower air density allows them to achieve a higher TAS for a given IAS, leading to faster ground speeds and improved fuel efficiency. Turbine engines are well-suited for high-altitude flight as their performance is less adversely affected by lower air density compared to normally aspirated piston engines, which require sufficient air density for efficient combustion.

A common rule of thumb for estimating TAS from IAS is to increase the IAS by approximately 2% for every 1000 feet of altitude gain. For typical general aviation speeds like 90 knots IAS, this can be simplified to adding about 2 knots to the IAS for every 1000 feet climbed.

- **Considerations**
- Piston engines are limited by low air density at high altitudes because they require sufficient air for the combustion process.
- Turbine engines are less affected by decreasing air density and can operate efficiently at high altitudes where there is also less drag.
- **Special Circumstances**
- If air density is different from the standard 1.225 kg/m^3 (e.g., at altitude or due to non-standard temperature), how does this affect airspeed readings? A density error will exist, meaning Indicated Airspeed will differ from True Airspeed. Specifically, as

air density decreases (e.g., with increasing altitude), True Airspeed will be higher than Indicated Airspeed for a given dynamic pressure.

Calculating True Airspeed (TAS) with CRP-5

> The CRP-5 flight computer is a mechanical calculator used by pilots to determine True Airspeed (TAS) by correcting Calibrated Airspeed (CAS) for variations in air density due to altitude and temperature.

- **Keypoints**
  - The CRP-5 is described as ‘designed for dummies’ due to its straightforward operation for these calculations.
  - Pressure altitude is typically represented in thousands of feet (e.g., ‘10’ for 10,000 ft).
  - Air temperature is given in degrees Celsius.
  - The inner circle on the airspeed scale is for CAS (or RAS).
  - The outer circle on the airspeed scale indicates TAS.
  - This skill is important for Phase 2 subjects.
  - The process can be reversed: if TAS is known, CAS can be found by reading from the outer to the inner scale after setting altitude and temperature.
  - The lecturer emphasizes going to the ‘airspeed’ circle and reading the part that says ‘airspeed’, typically in blue for TAS computations from Mach number or CAS.
  - The middle scale requires matching altitude (e.g. ‘10’ for 10,000 feet) with temperature (e.g. ‘10 degrees’).
- **Explanation**
  To calculate TAS using a CRP-5:

1. Locate the airspeed calculation window (often marked in blue, labelled ‘AIRSPEED’).
2. In the central part of this window, align your current pressure altitude (e.g., 10 for 10,000 feet on the ‘PRESSURE ALTITUDE x 1000 FT’ scale) with the Outside Air Temperature (OAT) in Celsius (e.g., 10°C on the ‘AIR TEMP °C’ scale). A red line can be used for precise alignment.
3. Once the altitude and temperature are set, this effectively sets the density correction.
4. Identify the inner and outer rotating scales. The inner scale is typically marked for Calibrated Airspeed (CAS or RAS - Rectified Airspeed).
5. Find your known CAS on the inner scale (e.g., for 100 knots, find the ‘10’ which represents 100).
6. Read the corresponding TAS on the outer scale directly opposite your CAS value. For example, with 10,000 feet, 10°C, and 100 knots CAS, the TAS would be 119

knots.

- **Examples**

  > Given: Pressure Altitude = 10,000 feet, Air Temperature = 10°C, Calibrated Airspeed (CAS) = 100 knots.

  - Align 10 (for 10,000 feet) on the pressure altitude scale with 10°C on the air temperature scale.
  - Find 100 (marked as ‘10’) on the inner CAS scale.
  - Read the TAS on the outer scale, which is 119 knots.

  > Given: Pressure Altitude = 20,000 feet, Air Temperature = -35°C. Students were asked to find the TAS.

  - Align 20 (for 20,000 feet) on the pressure altitude scale with -35°C on the air temperature scale.
  - (Assuming a CAS was provided or determined prior to this step by students) Find the CAS on the inner scale.
  - Read the TAS on the outer scale. The students collectively determined the answer to be 200 knots.

Airspeed Types and Corrections

> Aviation uses several types of airspeeds, derived by applying corrections for various errors. Key types include Indicated Airspeed (IAS), Calibrated Airspeed (CAS), Equivalent Airspeed (EAS), and True Airspeed (TAS).

- **Keypoints**
  - A common mnemonic mentioned, though disliked by the lecturer, is ‘ICE TEA’ (Indicated, Calibrated, Equivalent, True Airspeed). The lecturer’s explanation for the corrections was: To get CAS, correct EAS for position and instrument error. To get EAS out of CAS, correct for compressibility error. To get TAS out of EAS, correct for density error. (Note: The first step is non-standard; typically IAS is corrected for position/instrument error to get CAS).
  - The lecturer confirmed that Calibrated Airspeed (CAS) can be corrected for altitude and temperature error (density error) to give True Airspeed (TAS).
- **Explanation**
  The progression of airspeed corrections generally involves:

- Indicated Airspeed (IAS): Read directly from the airspeed indicator.
- Calibrated Airspeed (CAS): IAS corrected for instrument and position (installation) errors.
- Equivalent Airspeed (EAS): CAS corrected for compressibility error, which becomes significant at high speeds (above approx. 300 knots TAS) and high altitudes.

- True Airspeed (TAS): EAS (or CAS, if compressibility is negligible) corrected for air density variations (due to altitude and temperature). TAS is the actual speed of the aircraft through the air.

Density Error

> Density error arises because airspeed indicators are calibrated for standard sea-level density, but actual air density varies with altitude and temperature. True Airspeed (TAS) is obtained by correcting Calibrated Airspeed (CAS) or Equivalent Airspeed (EAS) for this density error.

- **Keypoints**
  - The higher you go, the lower the density.
  - The hotter it is, the lower the density.
  - The CRP-5 uses altitude and temperature inputs to correct for density error.
  - Correcting CAS for altitude and temperature error yields TAS.
- **Explanation**
  Air density decreases with increasing altitude and increasing temperature. The CRP-5 mechanically accounts for these changes. When you set altitude and temperature on the CRP-5, you are essentially inputting the factors that determine air density, allowing the instrument to calculate the correction from CAS to TAS. The difference between CAS and TAS is the density error.

Compressibility Error and Equivalent Airspeed (EAS)

> At high airspeeds (typically above 300 knots TAS), air behaves as a compressible fluid. This compressibility causes the pitot tube to sense a higher pressure than it would if the air were incompressible, leading to an over-reading of airspeed (CAS is higher than it should be). Correcting CAS for this compressibility error yields Equivalent Airspeed (EAS).

- **Keypoints**
  - Compressibility error becomes significant above approximately 300 knots True Airspeed.
  - Air compresses in front of and within the pitot tube at these speeds.
  - This compression leads to an increase in the indicated airspeed (CAS) reading.
  - Correcting CAS for compressibility error gives Equivalent Airspeed (EAS).
  - Compressibility is more likely at higher altitudes because aircraft fly at higher True Airspeeds to maintain lift in thinner air, even if maintaining a constant EAS or CAS.
  - If flying a constant EAS, as density decreases with altitude, TAS increases. Once TAS is high enough (e.g. >300 knots), compressibility becomes a factor, causing CAS to read higher for the same dynamic pressure.

- **Explanation**
  When an aircraft flies at high speeds (e.g., above 300 knots TAS, or a certain Mach number), the air particles start to compress as they enter the pitot tube. This compression results in an indicated airspeed (CAS) that is higher than the speed that would produce the same aerodynamic effects if compressibility were not a factor. EAS is the airspeed that would produce these same aerodynamic effects at sea level standard conditions. Stall speeds, when expressed as CAS or EAS, will increase at higher altitudes due to the compressibility effect, as aircraft need to fly at higher TAS to achieve the same EAS/CAS.

Pitot-Static System Malfunctions

> Blockages in the pitot tube or static ports lead to erroneous airspeed indications, which can be dangerous if not correctly interpreted by the pilot.

- **Explanation**
  The airspeed indicator works by measuring dynamic pressure, which is the difference between total pressure (from the pitot tube) and static pressure (from the static port(s)). Blockages affect these pressure inputs.
- **Considerations**
- Understanding the instrument's operation is crucial for diagnosing blockages, more so than memorizing mnemonics.
- The lecturer advises against relying solely on mnemonics like 'food, book, song' found in some training materials (e.g., Bristol).

Pitot Tube Blockage

> A blocked pitot tube traps the total pressure that was present at the moment of blockage. The airspeed indicator's behavior then depends on changes in static pressure (i.e., changes in altitude).

- **Keypoints**
  - If the pitot gets blocked while flying at a constant airspeed, the ASI will initially show the last airspeed before blockage.
  - A blocked pitot tube is a significant emergency.
- **Explanation**
  If the pitot tube is blocked (e.g., by ice, insects, or a cover):

- In level flight (constant altitude): The ASI will continue to show the airspeed at which the blockage occurred, as both trapped total pressure and ambient static pressure remain constant.
- During a climb: Ambient static pressure decreases. Since the trapped total pressure in the pitot line remains constant, the difference between total and static pressure (dynamic pressure) appears to increase. The ASI will therefore over-read. A pilot

misinterpreting this might reduce speed, potentially leading to a stall ('you will lower your speed, and you will slow the fucking thing, right?').

- During a descent: Ambient static pressure increases. The trapped total pressure remains constant. The difference (dynamic pressure) appears to decrease. The ASI will under-read. A pilot misinterpreting this might increase speed (pitch down) to regain indicated airspeed, potentially leading to exceeding aircraft speed limitations (over-speed).

- **Special Circumstances**
- If climbing with a blocked pitot tube, the ASI will over-read. Pilot action to reduce indicated speed could lead to a stall.
- If descending with a blocked pitot tube, the ASI will under-read. Pilot action to increase indicated speed could lead to over-speeding the aircraft.

Static Port Blockage

> A blocked static port traps the static pressure that was present at the moment of blockage within the airspeed indicator casing. The ASI will then give erroneous readings as the aircraft changes altitude because the total pressure from the (clear) pitot tube will change relative to this trapped static pressure.

- **Keypoints**
    - The lecturer's explanation: 'It under-rides during climb and over-rides during descent.'
- **Explanation**
  If the static port is blocked:

- During a climb: The actual static pressure decreases, so the total pressure sensed by the pitot tube (which is dynamic + actual static) also decreases. However, the static pressure inside the ASI casing is trapped at a higher value (from the lower altitude where blockage occurred). The ASI measures (Total Pressure - Trapped Static Pressure). As Total Pressure decreases and Trapped Static Pressure remains high, the indicated airspeed will under-read.
- During a descent: The actual static pressure increases, so the total pressure sensed by the pitot tube also increases. The static pressure inside the ASI casing is trapped at a lower value (from the higher altitude). As Total Pressure increases and Trapped Static Pressure remains low, the indicated airspeed will over-read.

- **Special Circumstances**
- If climbing with a blocked static port, the ASI will under-read.
- If descending with a blocked static port, the ASI will over-read.

Altimeter

> The altimeter is an aircraft instrument that measures altitude by sensing static air pressure. It incorporates a sealed aneroid capsule that expands or contracts with changes in static pressure, translating this movement via a linkage to a pointer on a calibrated dial.

- **Keypoints**
  - The altimeter measures static pressure.
  - It displays the difference between the actual static pressure and the subscale pressure setting.
  - It incorporates a sealed aneroid capsule.
- **Explanation**
  The altimeter works by comparing the ambient static pressure (obtained from the static port) to a reference pressure set by the pilot on the altimeter's subscale (e.g., QNH or QFE). The instrument displays the difference as an altitude. The key components are a sealed aneroid capsule surrounded by static air from a static source; a linkage connects this capsule to a pointer.

Outside Air Temperature (OAT) Measurement

> OAT gauges measure the temperature of the air outside the aircraft. These measurements can be subject to several errors.

- **Keypoints**
  - OAT gauges can have instrument error from manufacturing.
  - Environmental errors can occur due to heating from the sun or ice formation on the probe.
  - Friction heating (also known as ram rise) is a significant error at high speeds, especially in commercial aviation. The friction of air passing over the temperature probe generates heat, causing the gauge to read a higher temperature than the actual static air temperature. Commercial aircraft may display both Total Air Temperature (TAT), which includes ram rise, and Static Air Temperature (SAT) or OAT.
  - Friction heating is less of a concern for Phase 1 / general aviation due to lower speeds.
- **Explanation**
  OAT is typically measured using a temperature-sensitive element, often a strip of metal, exposed to the airflow. However, the reading can be affected by various factors.

Gyroscope Fundamentals

> A gyroscope is any object rotating around an axis that exhibits two main characteristics: rigidity in space and precession. Common examples include a

> bicycle wheel, an airplane propeller, or even a spinning ball. These characteristics are essential for their use in various instruments.

- **Keypoints**
  - Key characteristics: Rigidity in space and precession of forces.
  - Factors enhancing gyroscopic properties: increased mass, increased speed of rotation, and mass located further from the axis of rotation.
  - Speed of rotation is practically the most important variable factor, as mass and its distribution are design elements. Speed is imparted by an engine or other means and can be lost if the power source fails.
- **Explanation**
  Basically, as Mika said, it could be any object that is rotating around an axis. The wheel of a bike is a gyroscope. The propeller of an airplane is a gyroscope. An aircraft is a gyroscope. If I start spinning this ball, this could be a gyroscope, ok? Anything could be a gyroscope, ok? Now, to be a gyroscope it has to meet these two. First one is rigidity. So, for a gyroscope to be a gyroscope, ok, it needs a certain mass, ok? It needs a certain speed of rotation, right? And it also needs that the mass is at a certain distance from the axis of rotation, ok? Now, more mass means that these characteristics are going to be better. The mass being further away from the axis means better characteristics as well. And more speed also means better characteristics.
- **Examples**
  > The wheel of a bicycle acts as a gyroscope when spinning.
  > The propeller of an airplane is a gyroscope when rotating.
  > A ball, if spun, can act as a gyroscope.

- **Considerations**
- The speed of rotation is crucial; an engine or power source failure can cause the gyroscope to lose speed and its gyroscopic properties, impacting instrument accuracy.

Rigidity in Space

> Rigidity in space is a primary characteristic of a gyroscope, describing its tendency to maintain its orientation in space once it is spinning, provided it is not disturbed and does not lose speed.

- **Keypoints**
  - A gyroscope maintains its position relative to space, not relative to the Earth's surface or its center. This distinction is crucial because the Earth itself rotates.
  - As long as a gyroscope maintains its rotational speed, it will resist changes to its orientation.

- **Explanation**
  Ahora, estas características, la primera es la rigidez, la rigidez en el espacio, lo que esto significa es que a lo largo de que no muevas este gyroscope, tendrá la tendencia a mantener su posición en el espacio… as long as it doesn't lose its speed right it's not actually gonna fall right because it has this characteristic of the rigidity in space… It's important the part of in space. Why? Because the earth rotates, okay? But a gyroscope will maintain its position with relation to space, not to the ground, not to the center of the earth, okay? That's very important as well.
- **Examples**
  > A spinning top (referred to in the lecture as 'peonza' or 'spinner') illustrates rigidity in space. It has an axis and a rotating mass. As long as it maintains sufficient speed, it remains upright and spinning, resisting falling to one side due to its gyroscopic nature and rigidity in space.

  - …así que es por ejemplo, no se como se dice peonza, este chico que los niños usan, que solo giras… i don't know it's a spinner i call a spinner but basically as long as it doesn't lose its speed right it's not actually gonna fall right because it has this characteristic of the rigidity in space… a spinning top okay since it's a gyroscope it has this characteristic of rigidity in space as long as it doesn't lose its speed you have an axis a mass which is rotating right with a certain speed so you have a gyroscope as long as it doesn't, it doesn't lose its speed, going to remain spinning forever, okay? And it's going to remain straight. Why doesn't it fall to a side? Because it has, it's a gyroscope and it has the characteristic of rigidity in space, okay?

Precession

> Precession is the second key characteristic of a gyroscope. It describes the phenomenon where a force applied to a spinning gyroscope results in a movement or reaction that occurs 90 degrees later in the direction of rotation from where the force was applied.

- **Keypoints**
  - If a force is applied to a gyroscope, the resultant effect of that force will manifest 90 degrees from the point of application, in the direction of the gyroscope's spin.
- **Explanation**
  Precession is, that if I apply a force to a gyroscope, gyroscope, that force is going to add 90 degrees in the direction of the rotation, ok? You can see it in the video, like, basically the gyroscope is spinning like this, right? If you apply a force at this point, the force is going to actually apply 90 degrees in the direction of rotation, ok? And that's just how it is, ok? Don't ask me about the physics behind it, ok? Because I don't know them, but basically this is what happens with gyroscopes, ok? So if I have this ball of the world here, and I spin it like this, and I want to move it like this, ok? And I try to push it like this, it's actually going to push it, I'm actually going to

push it towards me, ok? try to push it like this it’s actually gonna move like this okay if it has the proper amount of speed of mass and the mass is far away enough from this axis of rotation okay remember the three characteristics that we need as well okay

Gyroscope Components and Degrees of Freedom

> A gyroscope consists of a spin axis around which it rotates, and it is often mounted in gimbals. Gimbals are rings that allow the gyroscope to pivot freely. The number of planes in which the gyroscope can rotate freely, facilitated by these gimbals, determines its degrees of freedom.

- **Keypoints**
  - A gyroscope has a spin axis.
  - Gimbals allow the gyroscope to rotate freely in one or more planes.
  - The number of independent planes of rotation (excluding the spin axis itself) are called degrees of freedom.
  - Typically, gyroscopes used in instruments have 1 or 2 degrees of freedom.
  - A gyroscope with 2 degrees of freedom can rotate around its spin axis, a vertical axis, and a horizontal axis freely.
  - Blocking rotation around one of these axes reduces its degrees of freedom.
- **Explanation**
  now basically a gyroscope. it’s going to have its spin axis, right? and then it’s going to have, depending on what we are going to use it for certain amount of gimbals ok? now, each gimbal will basically allow the gyroscope to rotate freely. in a basically a plane of rotation, right? now the amount of gimbals that we give it the amount of planes. that the gyroscope can rotate around we are going to call those planes degrees of freedom, ok? so we can give it 1 degree of freedom or 2 degrees of freedom basically, plus its spin axis, basically, so this would be the example of a gyroscope with 2 degrees of freedom right? because it can spin. you see, this would be, It’s spin axis, right? And then it can actually spin around the vertical axis, right? And around this horizontal axis, right? Free, completely, right? So it has two degrees of freedom in this case, okay? If it’s blocked, for example here, imagine that it can’t rotate around this axis, for example, and only around this one, then it only has one degree of freedom. And that’s it, okay?

Types of Gyroscopes

> Gyroscopes are categorized based on their degrees of freedom and how they are constrained or utilized in instruments. Different applications require different types of gyroscopes.

- **Keypoints**

- Red Gyros: These gyroscopes have only one degree of freedom.
- Space Gyros: These are completely free gyroscopes with two degrees of freedom, allowing them to move freely in space.
- Tight Gyroscopes (or Tied Gyroscopes): These also have two degrees of freedom, but one of these degrees of freedom is intentionally linked or ‘tied’ to the structure of the aircraft itself.

- **Explanation**
  We are going to use for different purposes different types of gyroscopes, okay? That’s it. Here they mention the red gyros have only one degree of freedom, okay? That’s the name they gave them. Then you have the space gyros. The space gyros… are just free, completely, they have two degrees of freedom and they can move freely, basically, and you have the tight gyroscopes, but basically, in this case, the tight gyroscopes have also two degrees of freedom, but in this case, one of those degrees of freedom is going to be tied to the structure of the aircraft itself, okay? So, imagine that I attach here this.

Turn Indicator

> An instrument that measures the rate of turn of an aircraft, specifically the rate of yaw in degrees per second. It uses a rate gyro with one degree of freedom.

- **Keypoints**
  - Measures rate of turn (yaw).
  - Uses a rate gyro with one degree of freedom.
  - Works on the principle of gyroscopic precession.
  - Typically has a mark for a standard rate one turn (3 degrees per second).
  - A rate one turn is 180 degrees in one minute or 360 degrees in two minutes.
  - Rate of turn is different from angle of bank.
- **Explanation**
  The turn indicator uses a rate gyro. If the aircraft yaws (e.g., to the left), a force is applied to the gyroscope. Due to precession, this force acts 90 degrees to the direction of rotation, causing the gyroscope to tilt. This tilt is mechanically linked to a needle that indicates the rate of turn. For example, if the aircraft yaws left, the force is applied at point A, but due to precession (spinning in a certain direction), it acts on point B, tilting the gyroscope, which moves the needle. The gyroscope is not free to move on the vertical axis, so forcing it to change position creates the precessing force.
- **Examples**
  > The instrument normally has a little mark indicating a 3 degrees per second rate of turn.

    - This is a standard value. 3 degrees per second equals 180 degrees in one minute (3 deg/sec * 60 sec = 180 deg), or 360 degrees in two minutes. This is called a “rate one turn” and is standard for IFR maneuvers.
- **Considerations**
- In IFR maneuvers you need to fly always rate 1 turns, whenever you turn in IFR.

Turn Coordination and the Slip/Skid Indicator (The Ball)

> The ball in the turn indicator (or turn coordinator) is a slip/skid indicator used to achieve coordinated flight, where the forces felt by occupants are primarily downwards, not sideways, during a turn. It helps balance the bank angle and the rate of yaw.

- **Keypoints**
    - The ball indicates if a turn is coordinated, slipping, or skidding.
    - Coordinated turn: bank and yaw are balanced, ball is centered. No lateral forces felt.
    - Slipping turn: Too much bank or insufficient rudder. Ball moves to the inside of the turn. Aircraft may lose altitude and turn radius may increase.
    - Skidding turn: Too much rudder or insufficient bank. Ball moves to the outside of the turn. Tail goes out of the turn, nose points too far into the turn.
    - Flying coordinated is important for passenger comfort and aircraft performance (reduces drag).
- **Explanation**
  In a coordinated turn, the centrifugal force due to yaw and the inward force due to bank are balanced. If a car turns, occupants feel a force to the outside of the turn (inertia). A car only yaws. If an aircraft banks, occupants would tend to fall towards the inside of the turn. The ball indicates this balance. If the ball is centered, the turn is coordinated. If too much bank is applied for the rate of yaw (or not enough rudder), the aircraft slips into the turn, and the ball moves to the inside of the turn (e.g., left bank, ball to the left). If too much rudder (yaw) is applied for the bank angle, the aircraft skids outwards, and the ball moves to the outside of the turn (e.g., left bank, ball to the right). The rule is “step on the ball”: if the ball is to the left, apply left rudder; if to the right, apply right rudder (or reduce opposite rudder).
- **Examples**
  > If you make a left turn with too much bank, the ball is going to go to the left, because the ball will fall to the left if you put too much bank.

    - The bank will make you sort of fall to the left. To compensate, you need to ‘step on the ball’, meaning apply more left rudder to increase yaw and center the ball.

  > If you make a turn with not enough bank and too much rudder, the ball will go to the right. (Assuming a left turn context from previous example). Whenever you

> have too much rudder, you say you're skidding… your nose is sort of looking into the circle… because you're applying too much rudder.

  - In a left turn with too much left rudder, the ball goes to the right. You need to reduce left rudder or apply right rudder to center it.
- **Considerations**
- If your ball is not centered, then your turn is not coordinated and the instructor will shout at you.
- Uncoordinated flight generates more drag and decreases performance.
- In commercial aviation, it's normally just for passenger comfort.
- **Special Circumstances**
- If encountering a slipping turn (e.g., ball to the left in a left turn), how should it be addressed? Apply left rudder ('step on the ball') to increase yaw relative to bank.
- If encountering a skidding turn (e.g., ball to the right in a left turn), how should it be addressed? Reduce left rudder or apply right rudder to decrease yaw relative to bank.

Turn Coordinator

> An advancement of the turn indicator that senses not only yaw but also a component of roll. This makes the instrument more responsive and less prone to lag.

- **Keypoints**
  - Senses both rate of yaw and rate of roll.
  - Gyroscope is tilted (canted) by about 30 degrees.
  - More responsive than a simple turn indicator.
  - Does NOT provide pitch information, even if it has an airplane symbol.
  - Often driven by an electrical motor in small planes.
  - May have a failure flag (e.g., turns red) if unserviceable.
- **Explanation**
  The turn coordinator's gyroscope is canted (tilted) upwards, typically by 30 degrees. This tilt allows the gyro to sense the initial roll of the aircraft as it enters a turn, in addition to the rate of yaw. If the gyro were not tilted, a pure roll would apply a force that the gyro couldn't respond to (as it's not free to move around the vertical axis in that configuration). Tilting it allows the roll input to cause a precessing force that moves the indicator.
- **Examples**
  > They tilt the gyroscope by 30 degrees normally, and that way instead of sensing only yaw, it will sense a little bit the roll as well.

  - If the gyro is not tilted and the aircraft rolls, the force on the gyro acts where it cannot move. By tilting it 30 degrees, roll input can cause a precessive force that the instrument can register, making it react to roll as well as yaw.
- **Considerations**
- It's a common mistake, and accidents or incidents have happened, because people looked at the turn coordinator (with an airplane symbol) instead of the attitude indicator in stressful situations.
- **Special Circumstances**
- If the turn coordinator fails (e.g., electrical failure), how is this indicated? A little indicator will become red, signifying the instrument is no longer working.

Gyroscope Suction System

> A system used to power some gyroscopic instruments by using a vacuum (suction) to spin the gyroscope. This is an alternative to electrical motors.

- **Keypoints**
  - Uses an engine-driven, non-electrical pump.
  - Pump creates a vacuum, sucking air through the gyro casing.
  - Air flowing over vanes on the gyro rotor causes it to spin.
  - System includes an air filter; may have a bypass.
  - A suction gauge indicates if the system is operating within the correct parameters (green arc).
  - Pumps are often designed with a shear point (plastic structure) to break if overloaded, preventing damage to the engine.
- **Explanation**
  An engine-driven pump creates a vacuum in the gyroscope's chamber. Air is drawn through vents or 'little wings' on the gyroscope rotor, causing it to spin at high speed. The air intake for this system usually has a filter. If the filter gets blocked, a bypass or secondary unfiltered air source might be available.
- **Examples**
  > The vacuum pump is designed so that if it generates too much force, its plastic structure breaks down (shears) instead of transmitting that excessive force back to the engine.

  - The pump has a deliberate weak point (plastic structure) that will shear or break if the pump creates excessive force. This prevents the excessive force from being transmitted back to the aircraft engine, which drives the pump, thus avoiding a more significant engine failure.
- **Considerations**
- The suction indication must be checked prior to flight to ensure it's within the green arc.

- **Special Circumstances**
- If the primary air filter for the suction system gets blocked, how is this handled? There is normally a bypass, or a secondary source of air (which won't have this filter) can be used.

Attitude Indicator (AI)

> An instrument that displays the aircraft's attitude relative to the Earth's horizon, showing both pitch (nose up/down) and bank (wings tilted left/right). It uses a gyroscope with two degrees of freedom (plus the spin axis).

- **Keypoints**
  - Indicates pitch and bank.
  - Uses a gyro with two degrees of freedom.
  - Spin axis is ideally vertical, pointing to the Earth's center.
  - Displays an artificial horizon (blue for sky, brown for Earth).
  - Requires an erection mechanism to correct for apparent drift due to Earth's curvature/rotation and aircraft movement.
  - Erection mechanism often uses gravity-sensitive pendulums.
- **Explanation**
  The AI features a symbolic airplane and an artificial horizon (blue for sky, brown for Earth). The gyroscope's spin axis is designed to remain vertically aligned (pointing towards the center of the Earth). This rigidity in space allows it to represent the horizon. However, due to the Earth's curvature and rotation, and aircraft movement over long distances, the gyro's alignment would appear to drift if not corrected. This correction is achieved by an erection mechanism, typically a pendulum system using gravity. Small weighted pendulums detect any tilt of the gyro's spin axis from the true vertical and apply corrective forces to precess it back to the correct alignment.
- **Examples**
  > If an aircraft flies from Spain to China, the gyroscope maintains its position in space, but its axis relative to the center of the Earth changes significantly. Without adjustment, it would indicate an unreal bank or pitch.

  - The gyroscope maintains its orientation in space. As the aircraft flies over a curved Earth, or as the Earth rotates, the fixed orientation of the gyro in space will no longer align with the local vertical. This would lead to erroneous pitch and bank indications. Therefore, a system is needed to continuously re-erect the gyro to the local vertical.

  > Gravity is used to keep the AI aligned with the center of the Earth. A mass is put on the bottom of the instrument, acting as a pendulum, to keep it pointing towards the center of the Earth.

- A pendulum system uses masses that, under the influence of gravity, detect any deviation of the gyro's spin axis from the vertical. These pendulums then act (e.g., by controlling air jets or mechanical means) to apply small precessing forces to the gyro, nudging it back into alignment with the true vertical.

Attitude Indicator

> The attitude indicator is a flight instrument that displays the aircraft's orientation (attitude) relative to the Earth's horizon. It provides the pilot with a visual representation of the aircraft's pitch (nose up/down) and bank (wings tilted left/right) angles. It relies on a gyroscopic mechanism that maintains a fixed orientation in space.

- **Keypoints**
  - Operational Principle: Utilizes a gyroscope, typically driven by suction from an engine-driven vacuum pump or electrically. The gyroscope's rotor spins at high speed, maintaining its orientation due to gyroscopic rigidity. The instrument casing, attached to the aircraft, moves around this fixed gyro.
  - Display: Features a miniature aircraft symbol fixed in the center of the display, representing the actual aircraft. A horizon bar separates the display into two halves, typically blue for sky and brown/black for ground. Markings indicate degrees of pitch and bank.
  - Components: Includes the bank angle scale (typically with markings at 10, 20, 30, 45, 60, 90 degrees), a sky pointer (indicating bank on the scale), the symbolic aircraft, and often flight director command bars (related to autopilot). Some may have a glide slope indicator for ILS approaches and a balance ball (inclinometer).
  - Operational Limits: In Instrument Approach and FAR (IAFAR) conditions, bank angles should generally not exceed 30 degrees. Normal flight operations typically use bank angles of 25-30 degrees. Markings for 45 and 60 degrees are present, but 60 degrees is usually only reached during specific maneuvers.
  - Pre-flight/Start-up: Requires a short period after engine start for the vacuum system to build pressure and the gyroscope to reach operational speed. An 'OFF' flag or similar indication may be visible until the gyro is stable.
  - Failure Indication: A red flag or similar warning indication typically appears if the instrument malfunctions (e.g., loss of vacuum, gyro failure).
- **Explanation**
  The core of the attitude indicator is a gyroscope with its spin axis oriented vertically (for most designs). Due to gyroscopic rigidity, this axis remains fixed in space (pointing towards the center of the Earth or perpendicular to the Earth's surface). The aircraft, along with the instrument's casing, maneuvers around this stable gyroscope. Linkages translate this relative movement into the visual display, where the miniature aircraft symbol shows its position relative to the horizon bar. For

example, if the aircraft pitches up, the horizon bar moves down relative to the miniature aircraft. If the aircraft banks right, the miniature aircraft appears to bank right relative to the horizon bar.

- **Considerations**
- Most errors related to the attitude indicator might be more related to the pump failing.
- Maybe with time, friction in the instrument makes the instrument somehow indicate an error.
- If the variants get worn or the instrument gets old, the gyroscope will start spinning slowly and that might be a typical error.

Direction Indicator (Heading Indicator)

> A flight instrument that provides a gyroscopically stabilized indication of the aircraft's magnetic heading. Unlike a magnetic compass, it is not north-seeking and is prone to drift, requiring periodic realignment with the magnetic compass.

- **Keypoints**
  - Operational Principle: Employs a gyroscope with its spin axis oriented horizontally, parallel to the Earth's surface. This gyroscope maintains its orientation in space (rigidity) once set. The instrument has two degrees of freedom to allow it to indicate heading changes without being affected by pitch or bank (within limits).
  - Display: Typically a circular card marked with 360 degrees, resembling a compass rose. The current heading is read against a lubber line or pointer.
  - Alignment: Must be manually (or automatically in some aircraft) aligned with the magnetic compass before flight and periodically during flight (e.g., every 15 minutes) to correct for precession.
  - Advantages over Magnetic Compass: Provides a stable heading indication, free from the oscillations, lag, and errors (like dip errors) that affect the magnetic compass during turns, acceleration, or deceleration.
  - Drift/Precession: Subject to errors causing it to drift from the set heading. These include: Real drift (Real Wonder) from instrument imperfections, and Apparent drift (Apparent Wonder) from Earth's rotation (up to 15 degrees/hour) and Transport Wander (aircraft movement over Earth's curved surface).
- **Explanation**
  The direction indicator's gyroscope is set to a known heading (usually from the magnetic compass). Due to its rigidity, it maintains this heading reference as the aircraft turns. The aircraft structure and instrument casing rotate around the gyroscope, and this rotation is displayed as a change in heading. Because it's not inherently north-seeking and is subject to precession (drift) due to mechanical

imperfections, Earth's rotation, and the aircraft's movement over the Earth, it requires regular alignment with the magnetic compass.

- **Examples**

  > When you are on the runway, how do you know if your direction indicator is actually working properly? It's aligned with the magnetic compass. It's aligned with the magnetic compass, and in this case with the runway numbers. For example, if on runway 27 (indicating 270 degrees magnetic), the direction indicator should also read 270 degrees after alignment.

  - This is a crucial pre-takeoff check to ensure the direction indicator is correctly set and functioning, using the known runway magnetic heading as a reference.
- **Considerations**
- You have to be constantly adjusting the direction indicator.
- In our case [modern aircraft] we don't have to do it because our aircraft do it automatically. Only in the Cessna 152, that's the only plane where we actually have to adjust the direction indicator with the magnetic compass.
- During taxi: If you turn left, [indicator] moves left. If you turn right, moves right. Or, another way of saying it, if you turn left, the numbers decrease. If you turn right, the numbers increase.
- **Special Circumstances**
- If the aircraft didn't bank, you would only need one degree of freedom [for the DI gyro]. But since the aircraft banks and you don't want the gyroscope to indicate any change into that banking, you need the gyroscope to have those two degrees of freedom.
- If this [taxi check behavior] doesn't go like this, something bad is happening. So you need to see what's going on, okay? You might want to go back to the counters and call the mechanics.

Magnetic Compass: Principles and Associated Errors

> The magnetic compass is a primary flight instrument that uses a freely pivoting magnetized needle to align with the Earth's magnetic field, thereby indicating magnetic north. It is mandatory on all aircraft due to its independence from aircraft power systems. However, it is subject to several inherent errors.

- **Keypoints**
  - Construction: Typically consists of one or more bar magnets attached to a compass card, pivoted and suspended in a liquid-filled bowl (often a kerosene-like fluid or viscous liquid) to dampen oscillations and reduce friction. The heading is read against a fixed lubber line.
  - Pre-flight Check: The glass must have no cracks, and the liquid needs to have no bubbles, as these can cause errors.

    - Reliability: Mandatory in all aircraft because it's very hard for it to fail completely.
    - Variation: The angular difference between True North (geographic) and Magnetic North. It varies by geographic location and over time. Charts depict isogonic lines. Burgos currently has 0 variation.
    - Deviation: Errors caused by local magnetic fields within the aircraft (metal structure, electrical equipment). It varies with aircraft heading. A deviation card, specific to each aircraft, lists corrections. Calibrated by 'compass swinging.'
    - Dip Errors: The Earth's magnetic field lines dip downwards towards the magnetic poles (except at the magnetic equator). This dip causes the compass needle to tilt, leading to acceleration/deceleration errors (ANDS: Accelerate North, Decelerate South in N. Hemisphere) and turning errors (UNOS: Undershoot North, Overshoot South in N. Hemisphere).
- **Explanation**
  The magnetic compass aligns with the horizontal component of the Earth's magnetic field. Variation accounts for the geographic difference between magnetic and true north. Deviation is aircraft-specific magnetic interference. Dip errors arise because the compass tries to align with inclined magnetic field lines, causing the needle to tilt. This tilt, combined with inertia, leads to erroneous readings during accelerations, decelerations, and turns, making the compass unreliable during these maneuvers. Mnemonics like ANDS and UNOS help pilots predict these errors.
- **Examples**
  > If you want to steer north, you actually have to point to 357 magnetic heading, or compass heading. If you want to go to 045, you actually have to point to 044. That's the deviation of the compass.

    - This illustrates how a pilot uses the deviation card to correct the desired magnetic course to the compass course they must steer to achieve it, compensating for the aircraft's specific magnetic interference.

  > If you are turning from west towards the north, the compass reading will stay at 3-3-0 or at 0-3-0, it will undershoot. And if you turn towards the south, it will overshoot. If you, imagine, turn from west to south, it will actually go all the way to 1-5-0.

    - This demonstrates the UNOS (Undershoot North, Overshoot South) mnemonic in practice for the Northern Hemisphere. When turning towards north, the pilot must roll out before the compass indicates north. When turning towards south, the pilot must roll out after the compass indicates south.
- **Considerations**
- The position of the magnetic north changes over time due to moving metals in the Earth's core.
- When using maps (which point to true north), variation must be applied to fly a magnetic heading.

- Winds in meteorological reports (METARs) are usually referenced to true north, requiring variation application.
- **Special Circumstances**
- A compass swing must be performed if: the accuracy of the compass is suspected to have decreased, any modification involving metals or replacing radio equipment occurs, or after a hard landing or severe turbulence.

Magnetic Compass Turning Errors (Undershoot/Overshoot in Northern Hemisphere)

> When an aircraft turns, the magnetic compass is subject to errors due to the magnetic dip effect on its center of gravity. These errors manifest as undershooting when turning to North and overshooting when turning to South in the Northern Hemisphere.

- **Keypoints**
  - When turning North (e.g., from East to North in the Northern Hemisphere), the compass undershoots by approximately 30 degrees.
  - When turning South in the Northern Hemisphere, the compass overshoots.
  - These errors are caused by the inertia of the tilted Center of Gravity (CG) of the compass due to magnetic dip.
  - The direction indicator (gyroscope) is more reliable for indicating heading during turns but requires periodic alignment with the magnetic compass during straight and level flight.
- **Explanation**
  The error is caused by the inertia of the compass's Center of Gravity (CG) being tilted due to magnetic dip. When turning from East to North (a left turn in the Northern Hemisphere), the compass will undershoot. The error is typically around 30 degrees. For example, even if the aircraft is actually pointing North, the compass might lag or show an incorrect reading reflecting this undershoot. The text mentions 'it will stay at zero for zero, for example' in this context. Conversely, when turning to the South, the opposite error (overshoot) occurs. Because of these inaccuracies during maneuvers, the direction indicator (which uses a gyroscope) is preferred, although it needs to be periodically aligned with the magnetic compass as it's not inherently tied to magnetic North.
- **Examples**
  > An aircraft is in the Northern Hemisphere, initially pointing East (090 degrees), and then makes a turn to the North (000 degrees).

  - The magnetic compass will undershoot due to the dip effect on its center of gravity.
  - Even though the aircraft is actually pointing North, the compass indication will lag or be incorrect. The text states, 'it will stay at zero for zero, for example.'

    - This error is normally approximately 30 degrees.
- **Considerations**
- The magnetic compass is generally not used for precise heading information during turns due to these inherent errors.
- The direction indicator (gyroscope) is the primary instrument for heading during turns, but it must be regularly cross-referenced and aligned with the magnetic compass during straight and level flight to correct for precession.
- **Special Circumstances**
- If turning to the North (e.g., from East) in the Northern Hemisphere, how should the magnetic compass reading be interpreted? Expect the compass to undershoot, meaning it will lag or indicate a heading up to approximately 30 degrees away from (to the East of, in a left turn from East) the actual Northern heading.
- If turning to the South in the Northern Hemisphere, how should the magnetic compass reading be interpreted? Expect the compass to overshoot, meaning it will lead or indicate a heading beyond the actual Southern heading.

Influence of Magnetic Dip and Latitude on Compass Errors

> Magnetic compass errors, such as turning and acceleration errors, are primarily caused by magnetic dip—the vertical component of the Earth's magnetic field. The severity of these errors is directly related to the geographical latitude.

- **Keypoints**
    - Magnetic dip is the vertical component of the Earth's magnetic field that causes the compass needle to tilt.
    - At the magnetic equator, there is no dip, so dip-related compass errors are non-existent.
    - At the magnetic poles, dip is maximum, and compass errors are largest; the needle tries to point vertically.
    - Compass errors due to dip increase with increasing latitude (i.e., moving from the equator towards the poles).
    - Dip effects and associated compass errors are reversed in the Southern Hemisphere compared to the Northern Hemisphere.
- **Explanation**
  Magnetic dip occurs because the Earth's magnetic field lines are not parallel to the surface everywhere except at the magnetic equator.
  At the Equator: The magnetic field is fully horizontal, so there is no dip. Consequently, dip-related compass errors are absent. The text states, 'basically there's no dip in the equator'.
  At Mid-Latitudes (e.g., around 40-something degrees, as mentioned for 'our case'): There is a significant vertical component (dip) to the magnetic field. This dip causes the compass needle to tilt, leading to errors during turns or acceleration. Some of

the magnetic field points towards the pole (horizontal component used for direction), and some points vertically (this vertical force is the dip).
At the Poles: The magnetic field is almost entirely vertical. The needle attempts to point straight down (North Magnetic Pole) or up (South Magnetic Pole), making the compass highly unreliable for horizontal direction, and errors are maximized.
General Trend: ‘The higher in latitude that you go, the closer to the poles that you go, the bigger the errors. The closer to the equator, the lower the error.’
Southern Hemisphere: The effects of dip are ‘basically flipped’ compared to the Northern Hemisphere.

- **Examples**

  > An aircraft is operating at the Earth’s magnetic equator.

  - At the equator, ‘The force of the magnetic field is fully horizontal’.
  - ‘There’s no vertical component to push the needle up or down’.
  - Therefore, magnetic compass errors caused by dip (like turning errors discussed) ‘is zero basically’, ‘there is no error at all’.

  > An aircraft is operating near one of the Earth’s magnetic poles.

  - Near the poles, the magnetic field is significantly tilted and has a large vertical component (dip).
  - This force ‘tilts the needle upwards, right?’ (or downwards depending on the pole and hemisphere).
  - ‘This force is the maximum when you’re in the pose [poles], right? When you’re in the pose, the needle wants to point directly downwards, right? Or directly upwards, in the solar chemistry [Southern Hemisphere], right?’
  - Consequently, ‘the bigger the errors’ are experienced closer to the poles.
- **Considerations**
- Pilots must be acutely aware of their latitude and the potential for increased compass unreliability in higher latitudes.
- In regions with significant magnetic dip, reliance on gyroscopic heading indicators (like the Direction Indicator) becomes more critical for accurate navigation.
- **Special Circumstances**
- If encountering flight operations at the equator, how should compass errors be addressed? Dip-related errors are negligible (‘zero basically’) at the equator.
- If encountering flight operations at high latitudes near the poles, how should magnetic compass readings be treated? Expect large and potentially unpredictable errors; primary reliance should be on other heading reference systems as the magnetic compass becomes very unreliable.

Electronic Flight Information Systems (EFIS) and Related Components

> Modern aircraft often utilize Electronic Flight Information Systems (EFIS) for displaying flight data. Key components include the Primary Flight Display (PFD), Horizontal Situation Indicator (HSI), and the Attitude and Heading Reference System (AHRS) that drives them.

- **Keypoints**
  - EFIS (Electronic Flight Information System) provides an electronic display of flight instruments.
  - A PFD (Primary Flight Display) is an electronic display typically showing the 'six-pack' of main flight instruments.
  - An HSI (Horizontal Situation Indicator) is often an integrated display combining attitude and heading information, sometimes referred to as AR HSI.
  - AHRS (Attitude and Heading Reference System) is a system, usually based on gyroscopes, that provides attitude and heading data to the EFIS displays, particularly the Attitude Indicator and HSI.
- **Explanation**
  EFIS (Electronic Flight Information System) is 'just an electronic flight information system'. It's essentially a modern way to present flight data.
  A PFD (Primary Flight Display) is a core part of EFIS. It's described as 'basically composed of the six-pack that we've seen, the main instruments, just in an electronic display like this one.'
  An HSI (Horizontal Situation Indicator) can be part of the PFD. It's mentioned as a 'mix between the Attitude Indicator and the Direction Indicator'. An 'AR HSI' is also mentioned.
  The Attitude Indicator and HSI are 'driven by the Attitude and Heading Reference System [AHRS]'.
  AHRS (Attitude and Heading Reference System) is 'just a setting of gyroscopes, used for the purpose of indicating these values' (attitude and heading).
  The lecture notes that specific details about display technology (e.g., 'type of, let's, say, the type of, how do you call it, like LEDs, right, that the display uses, or how the screen is built, basically') are 'not important for Phase 1'.
- **Considerations**
- Understanding that EFIS displays are driven by underlying sensor systems like AHRS is crucial for pilots.
- While EFIS provides a clear and integrated presentation of flight data, the fundamental principles of how attitude and heading are sensed (e.g., via gyroscopes) remain important.
- **Special Circumstances**
- If asked about the display technology of EFIS for Phase 1, how should it be addressed? Details like LED types or screen construction are 'not important for Phase 1'.

Assignments & Suggestions

- Students are to begin topic/lesson 12 on 2025-05-13.
- During pre-flight walk-arounds, always take a look inside the pitot tube to check for blockages.
- Do not blow into the pitot tube, as this can cause damage or decalibrate it.
- Always ensure the correct altimeter settings (e.g., QNH, Standard) are used in every single stage of a flight.
- When starting to fly, pay close attention to instructors or ATC insisting on correct QNH settings.
- Change altimeter setting to standard (1013 hPa) when passing 6,000 feet in Spain (unless in specific regions like Granada or Madrid with different transition altitudes).
- You'll have exercises on how to correct for altimeter mistakes.
- Prior to take off you should check the availability of your altimeter.
- Let's do a 20-minute break.
- For flight preparation using navlogs, estimate True Airspeed (TAS) by increasing the indicated airspeed (IAS) by approximately 2 knots for every 1000 feet of altitude. For example, if planning to fly at a cruising IAS of 90 knots, this adjustment should be applied for the planned altitude.
- Students were asked to calculate True Airspeed (TAS) with given parameters (20,000 feet altitude, -35 degrees Celsius temperature), arriving at an answer of 200 knots.
- The lecturer mentioned that students have to do a final test for each lesson, implying regular assessments.
- Understand the workings of airspeed indicators and altimeters, and the consequences of system blockages.
- Learn how to use the CRP-5 for airspeed calculations as it's relevant for Phase 2 subjects.
- You have to check the suction indication on gyro instruments prior to flight.
- Learn the formula for angle of bank for a rate one turn (TAS/10 + 7), as you will be asked for it later on.
- Review the remaining lesson in 'Del Vato', which consists of approximately eight slides. This material will be accessible from 2025-05-13.