2025-05-16 - Instruments Lecture 1

> Date & Time: 2025-05-16 18:04:39
> Location: [Insert Location]
> [Insert Title]
> `Aircraft Instrumentation` `Principle of Flight` `Exam Preparation`

Theme

This lecture provides a comprehensive review of aircraft instrumentation and the principles of flight, focusing on exam preparation for aviation students. Key topics include pitot-static systems, altimeter operations, airspeed indicators, gyroscopic instruments, and related errors. The session emphasizes understanding through visual aids, mnemonics, and practical exercises, with detailed guidance on exam schedules, preparation strategies, and the use of flight computers for calculations.

Takeaways

1. Review of instruments with reference to previous instruction by Mario
2. Use of pictures and videos to aid understanding of instrumentation
3. Coverage of alerting system and communications (two pages)
4. Preparation time allocated for UK program and board exam candidates
5. Principle of flight: importance of reading slides and doing question back
6. Exam schedule: Instrument exam on Monday, 2025-05-26
7. Recovery session/exam scheduled for Wednesday, 2025-05-28
8. POF (Principle of Flight) exam: 46 questions, 1 hour and 30 minutes duration
9. Discussion about delay between theory and exams
10. Clarification that the exam is not the same as previous students' or Bristol quiz

Highlights

- `"High to low, look below. Low to high, look in the sky."-- Speaker 1`
- `"If you memorize what's going to happen to true airspeed when you're increasing with the constant indicator, you can."-- Speaker 1`
- `"Practice at home and if you still don't understand, come back or even text me on Whatsapp and I'll tell you how to do it."-- Speaker 1`

- `"If you are going to leave these questions, you are never going to be able to solve them."-- Speaker 1`
- `"Gyroscopes don't make sense. Don't make sense. It's not real. It's not real. But I'm going to tell you the truth. It is real. It's a surprise."-- Speaker 1`

Chapters & Topics

Instrument Review and Preparation

> A review session for instruments is planned, referencing previous instruction by Mario. The session will include visual aids such as pictures and videos to enhance understanding. The alerting system and communications will also be covered briefly, as they comprise only two pages.

- **Keypoints**
  - Review of instruments with visual aids
  - Brief coverage of alerting system and communications
  - Preparation time for UK program and board exam candidates
- **Explanation**
  The instructor plans to quickly review the instruments, referencing prior work with Mario, and supplement the review with pictures and videos. After covering the alerting system and communications, students will have free time to prepare for upcoming exams.
- **Considerations**
- Ensure all students understand the instrumentation through visual aids
- Allocate sufficient preparation time for different exam requirements

Principle of Flight Exam Preparation

> Students are instructed to read through the slides for the principle of flight, as the exam content differs from previous years and the Bristol quiz. Completing the question back is recommended for better understanding.

- **Keypoints**
  - Read all slides thoroughly
  - Exam content is not identical to previous students' or Bristol quiz
  - Complete the question back for deeper understanding
- **Explanation**
  The instructor emphasizes the importance of reading the slides and doing the question back, as the exam will not be the same as previous versions. This approach is intended to ensure comprehensive understanding.

- **Considerations**
- Do not rely solely on past exams or quizzes for preparation
- **Special Circumstances**
- If students notice discrepancies between current and previous exam formats, they should focus on the current slides and question back for accurate preparation.

Exam Scheduling and Structure

> The instrument exam is scheduled for Monday, 2025-05-26, and the recovery session/exam is scheduled for Wednesday, 2025-05-28. The POF exam consists of 46 questions and lasts 1 hour and 30 minutes.

- **Keypoints**
  - Instrument exam: Monday, 2025-05-26
  - Recovery session/exam: Wednesday, 2025-05-28
  - POF exam: 46 questions, 1 hour and 30 minutes
- **Explanation**
  The exam schedule was discussed and confirmed among the speakers. The structure of the POF exam was clarified, including the number of questions and duration.
- **Considerations**
- Be aware of the gap between theory sessions and exams
- Note the exact dates and times for each exam
- **Special Circumstances**
- If students are concerned about the delay between theory and exams, they should communicate with the instructor for clarification.

Instrument Questions and Lessons

> The number of questions and timing for the instrumentation section, as well as the specific lessons covered.

- **Keypoints**
  - There are 60 questions for instruments.
  - The time allotted is one hour and 30 seconds.
  - Instrumentation is covered in lessons 12, 13, 14, 15, and 16.
  - Lesson 16 is only two pages.
- **Explanation**
  The instructor clarified that the instrumentation section consists of 60 questions, to be completed in one hour and 30 seconds. The relevant lessons are 12 through 16, with lesson 16 being notably brief.

Pitot-Static System: Components and Faults

> Understanding the pitot-static system, its components, typical faults, and maintenance procedures.

- **Keypoints**
  - The pitot-static system includes static ports (usually at the back or tail) and the pitot tube (on the wing, left or right).
  - Common faults include blocked pitot tube (by debris or icing) and blocked static port.
  - Covers must be used on pitot tube and static port when storing the aircraft and removed before flight.
  - Never blow into the pitot tube or static port to avoid damaging the sensitive system.
  - Pitot heat is used to prevent or remove icing.
- **Explanation**
  The instructor described the physical layout of the pitot-static system, emphasizing the importance of keeping the system clear of blockages and the use of pitot heat to prevent icing. Covers are used for protection during storage, and improper handling (such as blowing into the tubes) can cause damage.
- **Examples**
  > If the pitot tube is blocked by debris or ice, the airspeed indicator will not function correctly. Pitot heat can be used to melt ice, and the drain hole allows melted water to escape.

  - Check for debris before flight.
  - Use pitot heat if available.
  - Ensure covers are removed before flight.
- **Considerations**
- Always check for debris and blockages before flight.
- Do not blow into the pitot tube or static port.
- Check pitot heat functionality if equipped.
- **Special Circumstances**
- If pitot heat is not available (e.g., in some aircraft like Husserl), ensure extra vigilance for icing conditions.

Pitot Tube vs. Pitot-Static Head

> Differences between pitot tube and pitot-static head designs.

- **Keypoints**
  - Pitot tube requires a separate static port.

  - Pitot-static head combines pitot tube and static port in one unit.
  - Design differences do not affect function but affect installation.
- **Explanation**
  The instructor explained that the pitot-static head integrates both the pitot and static ports, while the pitot tube requires a separate static port elsewhere on the aircraft.

Serviceability Checks for Pitot Tube

> Procedures for checking the pitot tube before flight.

- **Keypoints**
  - Check for blockages and debris.
  - Check pitot heat if equipped.
  - Pitot pressure should match static pressure when stationary.
  - Check pitot tube operation during takeoff roll.
- **Explanation**
  Before flight, visually inspect the pitot tube for blockages and test pitot heat. During takeoff roll, verify that the airspeed indicator responds, indicating pitot tube functionality.
- **Considerations**
- Do not touch the pitot tube directly after activating pitot heat to avoid burns.

Altimeter Operation and Pressure Settings

> How the altimeter works, including QNH, QFE, and standard settings.

- **Keypoints**
  - Altimeter uses a pressure bellow or capsule with a partial vacuum inside and static pressure outside.
  - QNH is the local pressure setting; QFE is the pressure at a specific location (e.g., runway threshold).
  - Standard setting is 1013.25 hPa (29.92 inHg).
  - Changing QNH changes the indicated altitude to match airport elevation.
- **Explanation**
  The instructor described the mechanical operation of the altimeter and how different pressure settings (QNH, QFE, standard) affect the indicated altitude. QNH is commonly used for flight, while QFE is less common.
- **Examples**
  > If QNH in Burgos is 1019, set the altimeter to 1019 to display the airport elevation (2000,000 236 feet).

  - Check the current QNH.

    - Set the altimeter to the current QNH.
    - Verify the indicated elevation matches the airport elevation.
- **Considerations**
- Always set the correct QNH before flight.
- Adjust for daily pressure changes.
- **Special Circumstances**
- If QNH changes during flight, adjust the altimeter setting accordingly.

Transition Altitude and Flight Levels

> When to switch from QNH to standard setting and use flight levels.

- **Keypoints**
    - In Spain, transition altitude is 6000 feet.
    - Above 6000 feet, set altimeter to 1013 hPa and use flight levels (e.g., FL070 for 7000 feet).
    - All aircraft above transition altitude use the same standard setting for consistency.
- **Explanation**
  To avoid confusion from varying QNH values at different airports, all aircraft above a certain altitude (6000 feet in Spain) use the standard setting and refer to flight levels.
- **Considerations**
- Be aware of the transition altitude for the country of operation.

International Standard Atmosphere (ISA)

> Definition and parameters of the International Standard Atmosphere.

- **Keypoints**
    - ISA is defined as 15°C and 1013.25 hPa.
    - Used as a reference for performance calculations.
- **Explanation**
  ISA provides a standard reference for atmospheric conditions, used in performance and altitude calculations.

Pressure-Altitude Relationship

> How altitude changes with pressure and the conversion factors used.

- **Keypoints**
    - A change of 27 feet corresponds to a change of 1 hPa.
    - In exams, 30 feet per hPa may be used for easier calculations unless specified otherwise.

- **Explanation**
  When climbing or descending, pressure changes at a rate of 1 hPa per 27 feet. For exam purposes, 30 feet per hPa may be used if not otherwise specified.
- **Considerations**
- Use the correct conversion factor as specified in the exam.

True Altitude vs. Density Altitude

> Definitions and differences between true altitude and density altitude.

- **Keypoints**
  - True altitude is the actual height above sea level.
  - Density altitude is the altitude corrected for temperature and pressure, representing the altitude the aircraft 'feels' it is at.
  - Density altitude affects aircraft performance.
- **Explanation**
  True altitude is measured directly, while density altitude accounts for atmospheric conditions. High density altitude reduces performance; low density altitude improves it.
- **Examples**
  > At 5,000 feet, density altitude may be 7,000 feet or 6,000 feet depending on atmospheric conditions.

  - Check temperature and pressure.
  - Calculate density altitude.
  - Assess impact on aircraft performance.
- **Considerations**
- Monitor density altitude for performance planning.
- **Special Circumstances**
- If density altitude is high, expect reduced aircraft performance.

Aircraft Performance and Density Altitude

> How density altitude impacts aircraft performance, especially for different engine types.

- **Keypoints**
  - Higher density altitude means worse performance.
  - Lower density altitude means better performance.
  - Reciprocating engines are more affected by high density altitude than jet engines.

- **Explanation**
  Aircraft with reciprocating engines require denser air for optimal performance, while jet engines perform better at higher altitudes due to reduced drag.
- **Considerations**
- Consider engine type when planning for high-altitude operations.

Types of Altimeter Errors

> Different sources of error in altimeter readings.

- **Keypoints**
  - Instrument error: imperfections in design or construction.
  - Time lag: delay in indication during altitude changes.
  - Position error: placement of static port affects readings.
  - Maneuver-induced error: rapid maneuvers can cause temporary errors.
  - Temperature error: changes in temperature affect indicated vs. true altitude.
  - Barometric error: incorrect pressure setting affects readings.
- **Explanation**
  Each type of error arises from different causes, such as mechanical imperfections, delays in pressure changes, or environmental factors. Understanding these helps pilots interpret instrument readings accurately.
- **Considerations**
- Be aware of potential errors during flight, especially during rapid maneuvers or temperature changes.

Mnemonic Devices for Temperature and Pressure Errors

> Useful mnemonics to remember how temperature and pressure changes affect indicated altitude.

- **Keypoints**
  - “High to low, look below”: Going from high to low temperature or pressure, indicated altitude is higher than true altitude.
  - “Low to high, look in the sky”: Going from low to high temperature or pressure, indicated altitude is lower than true altitude.
- **Explanation**
  These mnemonics help pilots quickly recall how environmental changes affect their instruments, aiding in safer flight operations.
- **Considerations**
- Use mnemonics to avoid misinterpretation of altimeter readings.

Cockpit Instrument Presentations

> Different types of cockpit instrument displays and how to interpret them.

- **Keypoints**
  - Three-pointer analog presentation: small arrow for thousands, medium for hundreds, large for tens.
  - Drum pointer: used in high-flying aircraft, not common in general aviation.
  - Digital tape: modern displays (e.g., Garmin), with barometric pressure settings adjustable via knobs or buttons.
- **Explanation**
  Pilots must be familiar with various instrument presentations to accurately read altitude and other parameters.
- **Considerations**
- Practice reading different instrument types.

Barometric Pressure Setting Procedures

> How to adjust barometric pressure settings on different cockpit displays.

- **Keypoints**
  - Analog instruments use a barrel or knob.
  - Digital displays may require button presses and selection via knobs.
- **Explanation**
  Correctly setting the barometric pressure ensures accurate altitude readings.
- **Considerations**
- Familiarize yourself with the specific aircraft's procedure.

Static Source Blockage and Altimeter Behavior

> When the static source is blocked, the altimeter continues to measure the static pressure trapped in the system, displaying the altitude at which the blockage occurred, regardless of any subsequent climb or descent.

- **Keypoints**
  - If the blockage occurs at 5,000 feet, the altimeter will continue to read 5,000 feet.
  - Aircraft typically have two static ports and an alternate static port, making simultaneous blockage unlikely.
  - The altimeter will not reflect changes in altitude after blockage.
- **Explanation**
  If the static port is blocked, no new air enters the system, so the altimeter is stuck at the altitude where the blockage happened. This is critical for pilots to recognize, as it can lead to misjudging the aircraft's actual altitude.
- **Examples**

> If the static port is blocked at 5,000 feet, the altimeter will continue to display 5,000 feet even if the aircraft climbs or descends.

  - The static pressure in the system is trapped.
  - The altimeter cannot sense changes in altitude.
  - Pilots must be aware of this failure mode and use alternate static sources if available.
- **Considerations**
- Always check for proper static port function before flight.
- Know the location and operation of alternate static ports.
- **Special Circumstances**
- If both static ports are blocked, use the alternate static port if available.

Altimeter Deviation Tolerance and QNH Setting

> The maximum allowable deviation between the altimeter reading (after setting QNH) and the airport elevation (as per charts) is plus or minus 60 feet. Exceeding this requires maintenance intervention.

- **Keypoints**
  - Set QNH and compare altimeter reading to airport elevation.
  - Deviation must not exceed plus or minus 60 feet.
  - If deviation is more than 60 feet, flight is not permitted until maintenance is performed.
- **Explanation**
  Pilots must set the QNH (pressure setting) and check the altimeter against the known airport elevation. If the difference is within 60 feet, the instrument is considered serviceable. Otherwise, maintenance must be called.
- **Examples**
  > Before flight, the pilot sets the QNH and checks the altimeter reading against the airport elevation. If the difference is 70 feet, the aircraft cannot depart until maintenance checks the instrument.

  - Set QNH as per ATIS or METAR.
  - Read the altimeter and compare to charted airport elevation.
  - If deviation > 60 feet, do not proceed with flight.
- **Considerations**
- Always perform the QNH and elevation check before flight.
- Do not ignore deviations greater than 60 feet.
- **Special Circumstances**
- If deviation exceeds 60 feet, call maintenance and do not fly.

Vertical Speed Indicator (VSI) Operation and Errors

> The VSI measures the rate of climb or descent by comparing delayed and instantaneous static pressures. Errors can occur due to instrument lag, position, maneuver, and rapid altitude changes.

- **Keypoints**
  - VSI uses a narrow orifice to create a delay in static pressure.
  - Measures the difference between delayed and instantaneous static pressure.
  - Errors increase with rapid climbs or descents (e.g., 7,000 or 8,000 feet per minute).
  - Scale includes increments of 100, 200, 300, 400, 500, 1,000, 1,200, 1,400, 1,600, 1,800, 2,000 feet per minute.
- **Explanation**
  The VSI's delayed static pressure input causes it to lag behind actual altitude changes, especially during rapid maneuvers. Pilots must be aware of this lag and interpret VSI readings accordingly.
- **Examples**
  > During a rapid descent of 7,000 feet per minute, the VSI may not accurately reflect the true rate due to instrument lag.

  - Rapid pressure changes cannot be instantly registered due to the narrow orifice.
  - The instrument may under-read or over-read during sharp maneuvers.
- **Considerations**
- Understand the limitations of VSI during rapid altitude changes.
- Use other instruments to cross-check vertical speed during unusual maneuvers.
- **Special Circumstances**
- If VSI shows abnormal readings on the ground (e.g., +1,000 feet per minute), taxi back and do not fly.

Instantaneous Vertical Speed Indicator (IVSI)

> The IVSI is an improved VSI that uses a spring and accelerometer to provide more immediate readings of vertical speed, especially during rapid changes. However, it is susceptible to turbulence, which can cause erratic readings.

- **Keypoints**
  - IVSI includes a spring and bubble weight for rapid response.
  - Provides instantaneous vertical speed readings during rapid climbs or descents.
  - Turbulence causes the spring to expand and contract, resulting in fluctuating readings (e.g., +200, -200, +500, -300 feet per minute).

    - During turbulence, IVSI readings should be disregarded.
- **Explanation**
  The IVSI's design allows it to respond quickly to changes in vertical speed, but turbulence can cause the readings to become unreliable. Pilots are instructed to ignore IVSI indications during turbulent conditions.
- **Examples**
  > During turbulence, the IVSI may show rapidly changing readings such as +200, -200, +500, -300 feet per minute, which do not reflect actual vertical speed.

    - Turbulence causes the internal spring to move erratically.
    - Pilots must disregard IVSI readings in these conditions.
- **Considerations**
- Be aware of IVSI limitations in turbulence.
- Cross-check with other instruments if IVSI readings are erratic.
- **Special Circumstances**
- If encountering turbulence, disregard IVSI readings.

VSI Ground Tolerance

> On the ground, the VSI should read within plus or minus 200 feet per minute. Readings outside this range indicate a malfunction and require the aircraft to return to maintenance.

- **Keypoints**
    - Acceptable ground reading: +200 or -200 feet per minute.
    - If VSI shows +1,000 feet per minute on taxi, do not fly.
    - Tolerance is set to ensure instrument reliability before flight.
- **Explanation**
  Before takeoff, pilots check the VSI reading while taxiing. If the reading is within the specified tolerance, the instrument is considered serviceable. Otherwise, maintenance action is required.
- **Examples**
  > During taxi, the VSI reads +100 feet per minute, which is within tolerance and acceptable for flight.

    - Check VSI reading during taxi.
    - If within +200 or -200 feet per minute, proceed.
    - If outside this range, return for maintenance.
- **Considerations**
- Always check VSI reading before flight.
- Do not ignore abnormal VSI readings on the ground.

- **Special Circumstances**
- If VSI shows more than +200 or -200 feet per minute on the ground, taxi back and do not fly.

Airspeed Indicator Principles and Operation

> The airspeed indicator works by comparing total (pitot) pressure and static pressure. The difference between these pressures, after static pressure cancels out, gives dynamic pressure, which is then mechanically translated into an airspeed reading. Static pressure is essential for accurate readings at varying altitudes, as air density changes with altitude.

- **Keypoints**
  - Total pressure (pitot) and static pressure enter the instrument.
  - Static pressure cancels itself out inside and outside the bellow, leaving only dynamic pressure.
  - Dynamic pressure is proportional to airspeed.
  - Static pressure is needed to neutralize altitude effects on airspeed readings.
  - Indicated airspeed is what is shown on the instrument; true airspeed and ground speed are calculated differently.
- **Explanation**
  The airspeed indicator uses a diaphragm or bellow system. Total pressure enters one side, static pressure the other. The static pressure cancels out, so only dynamic pressure (caused by the aircraft's movement through the air) is measured. This is mechanically linked to the needle. Without static pressure, readings would be inaccurate at different altitudes due to changing air density.
- **Examples**
  > If you fly at 60 knots indicated airspeed at sea level, it will also show 60 knots at 6000 feet and 8000 feet, because static pressure compensates for altitude changes.

  - At higher altitudes, air density decreases.
  - Without static pressure compensation, the instrument would read zero at 6000 feet even if the aircraft is moving.
  - Static pressure ensures the indicated airspeed remains accurate regardless of altitude.
- **Considerations**
- Always use static pressure input for accurate airspeed readings.
- Understand the difference between indicated, true, and ground speed for navigation and performance calculations.
- **Special Circumstances**

- If static pressure source is blocked, indicated airspeed will be inaccurate and potentially dangerous.

Airspeed Indicator Errors and Calibration

> Airspeed indicators are subject to several types of errors, including instrument error, time lag, position error, and maneuver-induced error. Position error can be as much as plus or minus 10 knots. Calibration tables in the POH are used to correct indicated airspeed to calibrated airspeed.

- **Keypoints**
  - Instrument error: due to imperfections in the instrument.
  - Time lag: delay in pressure changes reaching the instrument.
  - Position error: caused by placement of pitot/static sources; can be up to ±10 knots.
  - Maneuver-induced error: due to aircraft attitude or maneuvers.
  - Calibration tables in the POH provide corrections from indicated to calibrated airspeed.
- **Explanation**
  Errors can cause the airspeed indicator to read incorrectly. Position error is often the largest, and is corrected by using tables in the Pilot Operating Handbook. These tables list the difference between indicated and calibrated airspeed for various flight conditions.
- **Examples**
  > If the airspeed indicator reads 120 knots, but the POH calibration table shows a +5 knot correction for that configuration, the calibrated airspeed is 125 knots.

  - Read the indicated airspeed (e.g., 120 knots).
  - Consult the POH calibration table for the current configuration.
  - Apply the correction (+5 knots) to get the calibrated airspeed (125 knots).
- **Considerations**
- Always check the POH for calibration tables during preflight planning.
- Be aware of potential errors, especially during maneuvers or unusual attitudes.
- **Special Circumstances**
- If position error exceeds ±10 knots, maintenance may be required.

Mnemonic for Airspeed Corrections: ICET (Indicated, Calibrated, Equivalent, True)

> A mnemonic helps remember the sequence of corrections needed to convert indicated airspeed to true airspeed: correct for instrument/position error to get

> calibrated airspeed, correct for compressibility to get equivalent airspeed, and correct for density to get true airspeed.

- **Keypoints**
  - Indicated Airspeed (IAS): what the instrument shows.
  - Calibrated Airspeed (CAS): IAS corrected for instrument and position error.
  - Equivalent Airspeed (EAS): CAS corrected for compressibility (important at high speeds).
  - True Airspeed (TAS): EAS corrected for air density (altitude and temperature).
- **Explanation**
  To get from IAS to TAS: first correct for instrument and position error (CAS), then for compressibility (EAS), then for density (TAS). The mnemonic 'Iced Tea is a pretty cool drink' helps remember the order: Indicated, Calibrated, Equivalent, True.
- **Examples**
  > If the indicated airspeed is 130 knots, and the POH shows a +3 knot correction, CAS is 133 knots. At high speed, apply a compressibility correction (e.g., -1 knot) to get EAS (132 knots). Then, using altitude and temperature, calculate TAS (e.g., 145 knots).

  - Start with IAS: 130 knots.
  - Apply calibration: +3 knots → CAS = 133 knots.
  - Apply compressibility: -1 knot → EAS = 132 knots.
  - Apply density correction (using formulas or flight computer): TAS = 145 knots.
- **Considerations**
- Remember the order of corrections for exam questions.
- Compressibility correction is usually only significant at high speeds (jets).
- **Special Circumstances**
- If flying at low speeds and altitudes, compressibility correction may be negligible.

CIT Mnemonic for Airspeed Relationships During Climb/Descent

> The CIT mnemonic (Calibrated, Indicated, True) helps determine how different airspeeds change relative to each other during climbs or descents when one speed is held constant. The method involves drawing a vertical line for the constant speed and using plus/minus signs to indicate whether the other speeds increase or decrease.

- **Keypoints**
  - CIT stands for Calibrated, Indicated, True airspeed.
  - When climbing with constant indicated airspeed, true airspeed increases, calibrated decreases.

    - When descending with constant indicated airspeed, true airspeed decreases, calibrated increases.
    - The position of plus/minus signs depends on whether climbing or descending.
    - This method is useful for answering exam questions about airspeed changes.
- **Explanation**
  To use the CIT mnemonic: choose which speed is constant, draw a vertical line through it, and assign plus/minus signs based on climb (nose up) or descent (tail up). For example, in a climb with constant indicated airspeed, true airspeed increases and calibrated decreases. This helps quickly answer questions without memorizing every scenario.
- **Examples**
  > If climbing with constant indicated airspeed, true airspeed will increase, calibrated airspeed will decrease.

    - Draw CIT: Calibrated, Indicated, True.
    - Hold indicated constant (vertical line).
    - In climb, nose is higher (plus on top, minus on bottom).
    - True airspeed increases, calibrated decreases.

  > If descending with constant true airspeed, both indicated and calibrated airspeed will increase.

    - Draw CIT: Calibrated, Indicated, True.
    - Hold true constant (vertical line).
    - In descent, tail is higher (plus on left, minus on right).
    - Indicated and calibrated airspeed increase.
- **Considerations**
- Practice using the CIT mnemonic for various scenarios.
- Remember the order of letters: C-I-T, not I-C-T.
- **Special Circumstances**
- If unsure, visualize the aircraft's attitude (nose up or down) to assign plus/minus signs correctly.

Ground Speed, True Airspeed, and Indicated Airspeed in Navigation

> Ground speed is the speed of the aircraft relative to the ground, used for navigation and time calculations. True airspeed is the actual speed through the air mass, and indicated airspeed is what the instrument shows. Ground speed is affected by wind, while true airspeed is not.

- **Keypoints**
    - Ground speed is used to calculate time between points (distance/time).
    - Ground speed is the speed relative to the terrain below.

- True airspeed is the speed through the air mass.
  - Indicated airspeed is what the instrument shows, affected by errors and altitude.
  - Ground speed can differ significantly from true airspeed due to wind.
- **Explanation**
  For navigation, always use ground speed to calculate how long it will take to travel between two points. True airspeed is used for performance calculations. Indicated airspeed is used for aircraft limitations and control. The difference between ground speed and true airspeed is due to wind.
- **Examples**
  > If ground speed is 138 knots and true airspeed is 146 knots, you will cover 138 nautical miles in one hour over the ground, even though you are moving at 146 knots through the air.

  - Ground speed = distance over ground / time.
  - True airspeed = speed through the air mass.
  - Wind can increase or decrease ground speed relative to true airspeed.
- **Considerations**
- Always use ground speed for navigation and time calculations.
- Be aware of wind effects when planning flights.
- **Special Circumstances**
- If wind is strong, ground speed may be much higher or lower than true airspeed.

Rule of Thumb for Airspeed Difference

> A very approximate rule of thumb states that the difference between calibrated airspeed and true airspeed is about 2% per 1000 feet of altitude gain.

- **Keypoints**
  - For every 1000 feet climbed, true airspeed increases by 2% over calibrated airspeed.
  - This rule is used for quick mental calculations when precise tools are unavailable.
- **Explanation**
  When climbing, for each 1000 feet, add 2% of the calibrated airspeed to estimate the true airspeed. For example, at 10,000 feet with a calibrated airspeed of 150 knots, calculate 2% x 10 = 20%, then 20% of 150 is 30, so true airspeed is approximately 180 knots.
- **Examples**
  > Given a calibrated airspeed of 150 knots at 10,000 feet, the difference is 2% per 1000 feet. 2% x 10 = 20%. 20% of 150 is 30. Add 30 to 150 to get 180 knots true airspeed.

    - Identify altitude: 10,000 feet.
    - Calculate percentage: 2% x 10 = 20%.
    - Find 20% of 150 knots: 0.2 x 150 = 30.
    - Add to calibrated airspeed: 150 + 30 = 180 knots.
- **Considerations**
- Always confirm whether to add or subtract the percentage based on climb or descent.
- **Special Circumstances**
- If you are unsure whether to add or subtract, remember that you add the percentage when climbing.

Using the Flight Computer (CRP-5)

> The CRP-5 flight computer is used to calculate various flight parameters, including converting calibrated airspeed to true airspeed using pressure altitude and temperature.

- **Keypoints**
    - The CRP-5 has sections for altitude, airspeed, density altitude, and unit conversions.
    - To compute TAS from CAS, align pressure altitude and temperature, then read the corresponding TAS value.
    - Each dot on the altitude scale represents 1000 feet.
- **Explanation**
  To find true airspeed, align the pressure altitude (e.g., 5000 feet) with the temperature (e.g., +5°C) on the flight computer. Then, locate the calibrated airspeed (e.g., 150 knots) and read the true airspeed from the outer scale (e.g., 162-163 knots).
- **Examples**
  > Given pressure altitude 5000 feet, temperature +5°C, and calibrated airspeed 150 knots, align +5°C with 5000 feet, find 150 knots on the inner scale, and read TAS as 162-163 knots.

    - Set pressure altitude (5000 feet) on the scale.
    - Align with temperature (+5°C).
    - Locate calibrated airspeed (150 knots) on the inner scale.
    - Read true airspeed (TAS) on the outer scale: 162-163 knots.
- **Considerations**
- Practice using the CRP-5 at home to become proficient.
- Read the accompanying book for detailed instructions.
- **Special Circumstances**

- If you forget the rule of thumb, use the CRP-5 for precise calculations.

Airspeed Indicator Errors

> Airspeed indicators can display incorrect readings due to pitot or static blockages, and understanding these errors is crucial for safe flight operations.

- **Keypoints**
  - Pitot block: Over-reads in climb, under-reads in descent.
  - Static block: Over-reads in descent, under-reads in climb.
  - On the ground, the airspeed indicator should read zero; on digital displays, it may read 20 knots due to pitot tube activation.
- **Explanation**
  If the pitot tube is blocked, the airspeed indicator will over-read during climb and under-read during descent. If the static port is blocked, the indicator will over-read during descent and under-read during climb.
- **Considerations**
- Memorize the effects of pitot and static blockages for exams and real-world application.
- **Special Circumstances**
- If the airspeed indicator shows abnormal readings, check for pitot or static blockages.

Errors in Outside Temperature Measurement

> Three main types of errors affect outside temperature measurement: instrument imperfection, solar heating, and ice accretion. Heating error is also significant for fast jets.

- **Keypoints**
  - Instrument imperfection: inherent inaccuracies in the thermometer.
  - Solar heating: direct sunlight can cause the thermometer to read higher than actual temperature.
  - Ice accretion: ice on the thermometer causes it to read lower than actual temperature.
  - Heating error: friction at high speeds increases thermometer readings.
- **Explanation**
  The outside temperature sensor, often a bimetallic strip, can be affected by direct sunlight (showing higher temperatures), ice (showing lower temperatures), and friction from high-speed flight (showing higher temperatures).
- **Considerations**
- Be aware of environmental factors that can affect temperature readings.

- **Special Circumstances**
- If flying in direct sunlight, expect higher temperature readings.
- If ice forms on the thermometer, expect lower readings.
- If flying at high speed, account for possible heating error.

Gyroscopic Instruments and Errors

> Gyroscopic instruments are essential for flight, but understanding their operation and potential errors is necessary for accurate navigation and control.

- **Keypoints**
  - Gyroscopes are used in several flight instruments.
  - Errors can occur if the operation of the gyroscope is not understood.
- **Explanation**
  The lecture notes that there was confusion about how gyroscopes work and the types of errors they can produce, indicating the need for further study and clarification.
- **Considerations**
- Clarify the operation and errors of gyroscopic instruments before exams.

Rigidity of Gyroscopes

> Rigidity refers to the inertia of the gyroscope, which is the property that makes the gyroscope continue spinning until acted upon by an external force. This is observed when a spinning object continues to spin even when pressed or its location is changed.

- **Keypoints**
  - Rigidity is the inertia of the gyroscope.
  - It allows the gyroscope to continue spinning until an external force acts on it.
  - Increasing the spin speed, mass, or effective radius increases rigidity.
  - Effective radius is the distance from the center of the axis to the end of the mass.
- **Explanation**
  Rigidity can be directly affected by increasing the spin speed, mass, or effective radius of the gyroscope. The more rigid the gyroscope, the longer and stronger it will resist changes to its spinning motion.
- **Examples**
  > When you spin a toy gyroscope, it continues spinning even if you press on it or change its location.

  - The gyroscope’s inertia keeps it spinning.
  - External force is required to stop or alter its motion.

    - This demonstrates the concept of rigidity.
- **Considerations**
- Increasing spin speed, mass, or effective radius increases rigidity.

Precession in Gyroscopes

> Precession is a special characteristic of a gyroscope where, when a force is applied at 90 degrees to the spinning axis, the gyroscope changes its spinning location or tilts. The resulting movement occurs at a point 90 degrees from where the force is applied.

- **Keypoints**
    - Precession occurs when a force is applied at 90 degrees to the spinning axis.
    - The gyroscope does not tilt in the direction of the force but rotates or tilts at a point 90 degrees away.
    - Precession is used in flight instruments.
- **Explanation**
  When a force is applied to a spinning gyroscope at 90 degrees, the gyroscope responds by moving at a point 90 degrees from the force application. This is crucial in understanding how gyroscopic instruments work in aircraft.
- **Examples**
  > When the aircraft turns, the gyroscope senses the yaw movement due to precession, and the instrument shows the turn direction.

    - A force (yaw) is applied to the gyroscope.
    - Due to precession, the movement is sensed at a point 90 degrees from the force.
    - The instrument’s mechanical linkage translates this into a turn indication.
- **Considerations**
- Do not confuse the direction of the aircraft turn with the direction the gyro turns due to precession.
- **Special Circumstances**
- If the gyroscope is not functioning (e.g., pump-driven gyro is off), the indicator will not work and the flag will show.

Gyroscope Components and Degrees of Freedom

> A gyroscope consists of a spin axis and one or more gimbals. Each gimbal allows movement in one plane, and the number of gimbals determines the degrees of freedom.

- **Keypoints**
    - Spin axis: the axis on which the gyroscope rotates.

- Gimbals: frames that allow the gyroscope to move in specific planes.
- Each gimbal adds one degree of freedom.
- Two gimbals = two degrees of freedom; three gimbals = three degrees, etc.

- **Explanation**
  The spin axis can be horizontal or vertical. The number of gimbals determines how freely the gyroscope can move. For example, two gimbals allow movement in two planes.
- **Examples**
  > A gyroscope mounted with two gimbals can rotate in two directions, giving it two degrees of freedom.

  - One gimbal allows rotation in one plane.
  - A second gimbal allows rotation in a perpendicular plane.
  - This setup is common in aircraft instruments.
- **Considerations**
- Identify the number of gimbals to determine degrees of freedom.

Types of Gyroscopes

> There are three main types of gyroscopes: rate gyros (one degree of freedom), space gyros (two degrees of freedom, also called free gyros), and tied gyros (two degrees of freedom, with one tied to a reference such as the aircraft's horizontal plane or Earth's vertical axis).

- **Keypoints**
  - Rate gyros: one degree of freedom, can rotate in only one plane.
  - Space gyros: two degrees of freedom, also called free gyros.
  - Tied gyros: two degrees of freedom, one tied to a reference (aircraft or gravity).
  - Some instruments, like the attitude indicator, use tied gyros.
- **Explanation**
  Rate gyros are used for measuring rates of turn. Space gyros are free to move in two planes. Tied gyros are constrained to a reference, making them suitable for indicating attitude relative to the aircraft or Earth.
- **Examples**
  > The attitude indicator uses a tied gyro, which is attached to the aircraft's horizontal plane.

  - The tied gyro maintains orientation relative to the aircraft.
  - It provides attitude information to the pilot.
- **Considerations**
- Remember the degree of freedom for each type of gyro.

Turn Indicator Instrument

> The turn indicator is an instrument that tells the pilot whether the aircraft is turning left or right and whether the rate of turn is correct (rate one turn). It uses a rate gyro to sense yaw and measure the rate of change in degrees per second or per minute.

- **Keypoints**
  - Indicates left or right turn and rate of turn.
  - Uses a rate gyro to sense yaw.
  - Shows if the turn is rate one (standard rate) or not.
  - Mechanical linkages translate gyro movement into instrument indication.
- **Explanation**
  When the aircraft turns, the nose tilts slightly, and the gyro senses this yaw movement. Due to precession, the gyro tilts and the instrument shows the turn direction. The rate one turn means a 360-degree turn in two minutes.
- **Examples**
  > If the indicator shows a rate one turn, a full 360-degree turn will take two minutes.

  - The pilot aligns the needle with the indicator.
  - Maintaining this rate completes a circle in two minutes.
- **Considerations**
- Do not confuse the direction of the aircraft turn with the direction the gyro turns.
- Understand the principle of gyroscopic precession in the instrument.
- **Special Circumstances**
- If the gyro is not powered (e.g., pump failure), the indicator will not work and the flag will show.

Turn and Slip Indicator Interpretation

> The turn and slip indicator uses a ball and needle to show the quality of the turn. The ball's position indicates whether the turn is coordinated, slipping, or skidding.

- **Keypoints**
  - Ball in the middle: coordinated turn.
  - Ball on the same side as the needle: slipping turn (mnemonic: pillow under the blanket, 'sleeping').
  - Ball on the opposite side: skidding turn.
  - Mnemonic: pillow (ball) and blanket (needle) analogy.
- **Explanation**
  If the ball is under the needle (blanket), the aircraft is slipping. If the ball is on the opposite side, the aircraft is skidding. This helps pilots correct their turns.

- **Examples**
  > If the ball is under the needle, imagine sleeping with a pillow under a blanket—this is a slipping turn.

  - Mnemonic helps remember the correct interpretation.
  - Visual aids (pictures from 2023) reinforce the concept.
- **Considerations**
- Use the mnemonic to quickly interpret the indicator.
- Check both ball and needle positions for accurate turn assessment.

Assignments & Suggestions

- Read through the slides for the principle of flight.
- Complete the question back for the principle of flight.
- Practice at home using the CRP-5 flight computer and read the accompanying book to understand how to find different parameters.
- Prepare for the exam by practicing calculation of true airspeed using both the rule of thumb and the CRP-5.
- If you do not understand any part, text or call the instructor for clarification.
- Bring the CRP-5 flight computer to class on Monday for further practice.
- Read through the section on calculation of TAS in the CRP-5 book.
- Watch the gyroscope instrument videos shared by the instructor.
- Review the pictures and mnemonics for slip and skid turns.
- Prepare questions for the next class on Monday, 2025-05-19.