2025-07-02 - GNav Lecture 2

> Date & Time: 2025-06-02 17:21:37
> Location: [Insert Location]
> [Insert Title]
> `map projections` `navigation calculations` `aviation charts`

Theme

This lecture provides a comprehensive overview of aviation navigation, focusing on map projections, navigation calculations, and the use of aeronautical charts. Key topics include types of map projections, great circle and rhumb line navigation, conformality, heading conversions, wind correction, airspeed types, and the use of flight computers for calculations. Practical examples and step-by-step procedures are provided to enhance understanding and proficiency in flight planning and navigation.

Takeaways

1. Types of map projections used in aviation: Lambert conformal conic and direct Mercator projection
2. Great circle and rhumb line concepts
3. Accuracy and application of different map projections for long and short distances
4. Conformality in map projections
5. Measurement of direction: true, magnetic, and compass headings
6. Variation and deviation: definitions and calculation rules
7. Scale of aeronautical charts (e.g., 1:500,000)
8. Distance conversions: nautical miles, statute miles, kilometers, feet, meters
9. Elevation depiction on maps: colors, contour lines, spot heights, hill shading
10. Importance of reading map legends for altitude and symbol interpretation

Highlights

- `"Directions, or theories, measured on a map are represented correctly."-- Speaker 1`
- `"Course means intended, and track means the actual."-- Speaker 1`
- `"The airspeed is the speed relative to the air mass, which the aircraft is flying inside. The ground speed is the speed relative to the ground`

`over which the aircraft is flying."-- Speaker 1`

- `"If the wind direction is given by text, so T, the wind direction should be true, so T, T. If the information is given by the ATC or anything, that you hear it, then if it's said by the mouth, by the M, so that the wind direction should be magnetic."-- Speaker 1`
- `"Knowing your ground speed and knowing how many nautical miles you cover in a minute, you can easily calculate the distance that you're going to fly in whatever time instructor will ask you."-- Speaker 1`
- `"I have to make sure you know it."-- Speaker 1`

Chapters & Topics

Types of Map Projections in Aviation

> Aviation uses primarily two types of map projections: the Lambert conformal conic projection and the direct Mercator projection. Each has specific applications based on flight distance and navigational needs.

- **Keypoints**
  - Lambert conformal conic projection uses an imaginary cone placed inside the Earth, projecting the Earth’s surface onto the cone.
  - Direct Mercator projection uses an imaginary cylinder with its axis coincident with the Earth’s polar axis.
  - Lambert conformal is most accurate for long-distance flights (e.g., London to Sydney), as it represents great circles.
  - Direct Mercator is best for short distances and is commonly used for VFR charts, representing rhumb lines.
- **Explanation**
  The Lambert conformal conic projection is created by placing a cone inside the Earth and projecting the surface onto it. When flattened, it does not include the entire surface and is less accurate for short distances. The direct Mercator projection uses a cylinder, making it suitable for small areas and short flights, as straight lines on this map are rhumb lines, which are easier to measure and follow.
- **Examples**
  > For a flight from London to Sydney, the Lambert conformal conic projection is used because it accurately represents the great circle route, which is the shortest distance between two points. For a flight from Burgos to Logroño, the direct Mercator projection is used because it is more accurate for short distances and easier to use for navigation.

  - Identify the flight distance and route.

    - Select the appropriate map projection based on distance: Lambert conformal for long, direct Mercator for short.
    - Use the map to plot the route and measure directions accordingly.
- **Considerations**
- Choose the map projection based on the flight distance.
- Understand the type of line (great circle or rhumb line) represented on each projection.
- **Special Circumstances**
- If flying a route that crosses many meridians at varying angles, use the Lambert conformal conic projection for accuracy.
- If flying a short, local route, use the direct Mercator projection for ease of measurement.

Great Circle and Rhumb Line

> A great circle is the shortest path between two points on a sphere, while a rhumb line crosses all meridians at the same angle and represents a constant direction.

- **Keypoints**
    - Great circles are used for long-distance navigation but are difficult to measure and fly due to constantly changing direction.
    - Rhumb lines are easier to measure and follow, especially on direct Mercator projections.
- **Explanation**
  On a Lambert conformal conic projection, a straight line represents a great circle, which is the shortest distance between two points. On a direct Mercator projection, a straight line is a rhumb line, which maintains a constant direction and is easier to use for navigation over short distances.
- **Examples**
  > A flight from Madrid to Abu Dhabi uses a great circle route for efficiency. The direction changes as the aircraft crosses different meridians.

    - Plot the route on a Lambert conformal conic map.
    - Note the changing angles as the route crosses meridians.
    - Adjust heading as needed during flight.
- **Considerations**
- Great circles are not simple to fly due to changing headings.
- Rhumb lines are preferred for short, straightforward routes.
- **Special Circumstances**
- If a flight requires constant heading, use a rhumb line on a direct Mercator projection.

Conformality in Map Projections

> Conformality, or orthomorphism, means that directions and shapes on the map are represented correctly, with parallels of latitude crossing meridians of longitude at right angles.

- **Keypoints**
  - A conformal map preserves angles and shapes of ground features.
  - Parallels and meridians must intersect at right angles for conformality.
  - Shapes of cities, towns, and other features should match real life.
- **Explanation**
  A map is conformal if it accurately represents angles and shapes. For example, the Direct Linear Cut-off Projection Conformal BFAR map is described as conformal because it meets these criteria.
- **Examples**
  > A VFR chart is checked to ensure that the angles between latitude and longitude lines are right angles and that the shapes of towns match their real-world appearance.

  - Examine the map’s grid structure.
  - Compare ground features to real-world shapes.
  - Confirm that angles are preserved.
- **Considerations**
- Check for conformality when selecting a map for navigation.
- **Special Circumstances**
- If a map is not conformal, be cautious when measuring angles and plotting courses.

Measurement of Direction: True, Magnetic, and Compass Headings

> Directions on maps are measured in true degrees. To convert between true, magnetic, and compass headings, variation and deviation must be considered.

- **Keypoints**
  - True direction is measured from geographic north.
  - Magnetic direction accounts for variation between true north and magnetic north.
  - Compass direction includes deviation caused by the aircraft’s magnetic field.
  - The rule for conversion: when going from right to left, west is plus, east is minus.
- **Explanation**
  To convert from true to magnetic heading, add west variation and subtract east

variation. To convert from magnetic to compass heading, add west deviation and subtract east deviation. Practice problems help reinforce this rule.

- **Examples**
  > Given: Compass heading is 1.3, deviation is 5 west, variation is 5 east. Calculate the magnetic heading.

  - From compass to magnetic: 1.3 + 5 (west deviation) = 6.3.
  - From magnetic to true: 6.3 - 5 (east variation) = 1.3.
- **Considerations**
- Always apply the correct sign for variation and deviation.
- Practice with different values to become proficient.
- **Special Circumstances**
- If unsure of the direction of variation or deviation, refer to the map legend or aircraft documentation.

Scale of Aeronautical Charts

> Aeronautical charts use specific scales, such as 1:500,000, meaning that 1 unit on the map equals 500,000 units in reality.

- **Keypoints**
  - 1 centimeter on the map equals 500,000 centimeters on the ground.
  - 1 inch equals 500,000 inches.
  - Scale affects the level of detail and area covered.
- **Explanation**
  Understanding the scale is crucial for accurate distance measurement and navigation. Always check the scale before using a map.
- **Examples**
  > A map with a scale of 1:500,000 is used to measure the distance between two cities. 2 centimeters on the map equals 1,000,000 centimeters (10 kilometers) in reality.

  - Multiply the map distance by the scale factor.
  - Convert units as needed.
- **Considerations**
- Always verify the scale before measuring distances.
- **Special Circumstances**
- If using a map with an unfamiliar scale, consult the legend for conversion factors.

Distance Conversions

> Conversions between nautical miles, statute miles, kilometers, feet, and meters are essential for navigation.

- **Keypoints**
  - 1.2 nautical miles = 1.15 statute miles = 1.85 kilometers.
  - 1.2 nautical miles = 6,080 feet.
  - 1 kilometer = 1,000 meters.
  - 1 meter = 3.28 feet (or use 3.5 for rough calculation).
- **Explanation**
  Use the provided conversion factors to quickly convert between units during navigation. For example, to convert 1,200 meters to feet, multiply by 3.28 to get 3,936 feet.
- **Examples**
  > Convert 1,200 meters to feet using the factor 1 meter = 3.28 feet.
  - 1,200 x 3.28 = 3,936 feet.
- **Considerations**
- Memorize key conversion factors for quick calculations.
- **Special Circumstances**
- If a precise conversion is not needed, use 1 meter = 3 feet for mental math.

Elevation Depiction on Maps

> Elevation is shown using colors, contour lines, spot heights, and hill shading. Each method provides information about terrain height and shape.

- **Keypoints**
  - Colors indicate elevation ranges (e.g., yellow for 2,500 feet, dark brown for 3,000 feet).
  - Contour lines join points of equal elevation; close spacing indicates steep slopes.
  - Spot heights show exact elevation, usually for summits.
  - Hill shading simulates sunlight from the northwest to show terrain relief.
- **Explanation**
  Check the map legend to interpret colors and symbols. Contour lines help identify steep or shallow terrain. Spot heights and hill shading provide additional detail.
- **Examples**
  > On a map, the area around Burgos is colored yellow, indicating an elevation of 2,500 feet. A spot height in a white box shows the highest elevation in the area.
  - Refer to the legend for color meanings.
  - Identify contour lines and spot heights for precise elevation.

- **Considerations**
- Always consult the legend for color and symbol meanings.
- Understand the vertical interval between contour lines.
- **Special Circumstances**
- If using a new map, review the legend before navigation.

Earth's Rotation

> The Earth rotates 15 degrees per hour, which is important for time and navigation calculations.

- **Keypoints**
  - Used in exam questions and navigation planning.
  - Affects calculation of time zones and longitude.
- **Explanation**
  Remember that the Earth rotates 15 degrees each hour. This information is essential for certain navigation and exam questions.
- **Examples**
  > If two locations are 30 degrees apart in longitude, the time difference is 2 hours.

  - Divide the longitude difference by 15 degrees per hour.
- **Considerations**
- Memorize the rotation rate for exams.
- **Special Circumstances**
- If unsure, refer to navigation textbooks or exam materials.

Math Checklist for Map Use

> Before using a map, check the date, coverage, terrain depiction, and airfield markings to ensure suitability for the intended flight.

- **Keypoints**
  - Verify the map's date to ensure it is current.
  - Check coverage to confirm the area includes your route.
  - Review how terrain and airfields are depicted.
  - Note whether elevation is shown in feet or meters.
- **Explanation**
  A checklist helps ensure that the map is appropriate for the planned flight. Missing or outdated information can lead to navigation errors.
- **Examples**

> Before flying from Burgos to Logroño, confirm that the map covers both locations and that terrain and airfields are clearly marked.

  - Check the map’s date and coverage area.
  - Review the legend for terrain and airfield symbols.
- **Considerations**
- Always perform a map checklist before flight.
- **Special Circumstances**
- If the map does not cover your route, obtain a suitable map before proceeding.

Conformal Charts

> In the context of analytical charts, ‘conformal’ means that the directions measured on the chart are a correct representation of the directions on the Earth.

- **Keypoints**
  - Conformal charts preserve angles, ensuring that measured directions correspond to true Earth directions.
  - Important for accurate navigation and plotting courses.
- **Explanation**
  [Speaker 1] explained that conformal means the direction measured on the chart matches the real direction on Earth, which is essential for navigation.

Triangle of Velocities (T-O-V)

> A graphical method used in flight to resolve the relationship between aircraft heading, wind, and ground track.

- **Keypoints**
  - Used to calculate wind correction angle, ground speed, headwind, and crosswind components.
  - Represents the vector addition of airspeed and wind to determine ground speed and track.
  - Essential for flight planning and navigation.
- **Explanation**
  [Speaker 1] described the triangle of velocities using the analogy of a boat in a river, where the sailor must point into the flow to reach the intended destination. The same principle applies to aircraft correcting for wind.
- **Examples**
  > A sailor in a boat must point the nose into the flow to counteract the current and reach the intended point. If not corrected, the boat will drift off course.

  - If the sailor does not correct for the flow, he will end up off course.

    - By pointing into the flow, the sailor compensates for the current and reaches the intended destination.
    - This is analogous to an aircraft correcting for wind.
- **Considerations**
- Always calculate wind correction angle to avoid drifting off the intended track.
- Use the triangle of velocities for accurate heading and ground speed determination.
- **Special Circumstances**
- If the wind changes during flight, recalculate the triangle of velocities to adjust heading and ground speed.

Track, Course, and Heading

> Track is the actual or desired path of the aircraft over the ground. Course is the intended path, and heading is the direction the aircraft is pointed.

- **Keypoints**
    - Track: Actual or desired path over the ground.
    - Course: Intended path (sometimes used interchangeably with track, but strictly means intended).
    - Heading: The direction the aircraft's nose is pointed.
    - Track Made Good (TMG): The actual track achieved, considering wind and other factors.
- **Explanation**
  [Speaker 1] clarified the differences between track, course, and heading, emphasizing that course is the intended path, track is the actual path, and heading is the direction the aircraft is pointed. The term 'Track Made Good' (TMG) refers to the actual track achieved.
- **Examples**
  > A pilot intends to fly from point A to B (course), but due to wind from the left, the actual track (TMG) is below the destination if not corrected.

    - Pilot sets a course from A to B.
    - Wind from the left causes drift.
    - Without correction, the aircraft's actual track (TMG) is off the intended destination.
    - Correction involves adjusting heading into the wind.
- **Considerations**
- Always distinguish between intended course and actual track for accurate navigation.
- Use TMG in exams as recommended.

Wind Correction Angle, Headwind, and Crosswind Components

> Wind correction angle is the angle between the track and heading required to compensate for wind. Headwind and crosswind components are the projections of wind along and across the aircraft's path.

- **Keypoints**
  - Wind correction angle ensures the aircraft stays on the intended track.
  - Headwind component affects ground speed; crosswind component affects drift.
  - Calculation is essential for safe and efficient flight.
- **Explanation**
  [Speaker 1] explained how to calculate wind correction angle, headwind, and crosswind components using the triangle of velocities and tools like the E6BX website or CFP5.
- **Examples**
  > Given a true course of 180, true airspeed of 95, wind from 275 at 20 knots, the wind correction angle is 12, heading is 192, and ground speed is 95.

  - Input true course, airspeed, wind direction, and speed into E6BX.
  - The tool calculates wind correction angle, required heading, and ground speed.
  - Example: wind correction angle 12, heading 192, ground speed 95.
- **Considerations**
- Use available tools for calculations during planning; CFP5 is recommended for exams.
- Double-check calculations to ensure accuracy.
- **Special Circumstances**
- If wind data changes en route, recalculate wind correction angle and components.

Flight Time and Fuel Consumption Calculation

> Flight time is calculated based on distance and ground speed. Fuel consumption is determined by multiplying flight time by the aircraft's fuel consumption rate.

- **Keypoints**
  - Flight time = Distance / Ground Speed.
  - Fuel consumption = (Flight time in hours) × (Fuel consumption rate per hour).
  - Example: For 20 nautical miles at 95 knots, flight time is 12 minutes 38 seconds; at 18 liters/hour, fuel used is 3.79 liters.
- **Explanation**
  [Speaker 1] demonstrated using the E6BX website to calculate flight time and fuel consumption for a given distance and ground speed, with specific examples and rates for different aircraft types.

- **Examples**
  > For a 20 nautical mile leg at 95 knots ground speed, flight time is 12 minutes 38 seconds. With a cruiser fuel consumption of 18 liters/hour, fuel used is 3.79 liters.

  - Calculate flight time: 20 NM / 95 knots = 12 minutes 38 seconds.
  - Multiply by fuel consumption rate: (12.633 minutes / 60) × 18 liters = 3.79 liters.
- **Considerations**
- Use accurate fuel consumption rates for the specific aircraft.
- Account for multi-engine aircraft by doubling the rate (e.g., 36 liters/hour for two engines).
- **Special Circumstances**
- If actual fuel consumption differs from planned, recalculate for safety.

Wind Correction and Drift Calculation

> The process of determining the necessary heading adjustment to compensate for wind drift, ensuring the aircraft maintains its intended track. This involves aligning the navigation tool (such as CRP-5) with the true airspeed, setting wind direction, measuring wind strength, and calculating drift angle and corrected heading.

- **Keypoints**
  - Align the navigation tool with true airspeed (e.g., 100 knots).
  - Set wind direction (e.g., 360 degrees).
  - Measure wind strength (e.g., 30 knots).
  - Determine drift angle (e.g., 17 degrees to the right).
  - Correct heading by subtracting drift from intended heading.
  - Calculate ground speed after correction.
- **Explanation**
  In the class, [Speaker 1] led the group through a step-by-step process using a navigation tool. The group set the true airspeed to 100, wind direction to 360, and measured 30 knots of wind. The drift was found to be 17 degrees to the right, so the correction was to turn left by 17 degrees. The corrected heading was calculated as 073 degrees, and the ground speed was determined to be 96.7 knots.
- **Examples**
  > Given true airspeed of 100 knots, wind direction 360, wind strength 30 knots, drift 17 degrees to the right. Correction: turn left by 17 degrees. Heading: 073. Ground speed: 96.7 knots.

  - Align the navigation tool with true airspeed (100 knots).
  - Set wind direction to 360.
  - Measure 30 knots down from the reference point.

  - Mark the drift (17 degrees to the right).
  - Correct heading by subtracting drift from intended heading (90 - 17 = 73).
  - Read ground speed as 96.7 knots.
- **Considerations**
- Always verify wind direction and strength before calculation.
- Ensure correct alignment of navigation tool for accurate results.
- **Special Circumstances**
- If the drift is to the right, correct by turning left; if to the left, correct by turning right.

True Airspeed vs Ground Speed

> True airspeed (TAS) is the speed of the aircraft relative to the air mass it is flying in, while ground speed (GS) is the speed of the aircraft relative to the ground. The difference between TAS and GS is determined by the wind component (headwind or tailwind).

- **Keypoints**
  - Headwind reduces ground speed compared to true airspeed.
  - Tailwind increases ground speed compared to true airspeed.
  - Ground speed = true airspeed ± wind component (subtract for headwind, add for tailwind).
- **Explanation**
  [Speaker 1] explained that if true airspeed is 90 knots and headwind is 20 knots, ground speed is 70 knots. If tailwind is 20 knots, ground speed is 110 knots. The analogy of a boat in a river was used: going against the flow slows you down relative to the ground, going with the flow speeds you up.
- **Examples**
  > True airspeed: 90 knots. Headwind: 20 knots. Ground speed: 70 knots. Tailwind: 20 knots. Ground speed: 110 knots.

  - With headwind: 90 - 20 = 70 knots.
  - With tailwind: 90 + 20 = 110 knots.

  > If a boat is stationary in a river with a 5 knot current, ground speed is 5 knots, true airspeed (or speed through water) is 0.

  - If engine is off, boat drifts with current.
  - Ground speed equals current speed (5 knots), true airspeed is 0.
- **Considerations**
- Always distinguish between airspeed and ground speed in calculations.
- Remember that wind direction and strength directly affect ground speed.
- **Special Circumstances**

- If stationary with a tailwind, ground speed equals wind speed, true airspeed is zero.

Wind Direction: True vs Magnetic

> Wind direction can be reported in either true or magnetic degrees. In written (text) reports, wind direction is given in true degrees. When communicated verbally (e.g., by ATC), wind direction is given in magnetic degrees. This distinction is important for navigation and runway alignment.

- **Keypoints**
  - Text reports (e.g., METAR) use true degrees for wind direction.
  - Verbal reports (e.g., ATC) use magnetic degrees.
  - Mnemonic: T for text = true, M for mouth = magnetic.
  - Runway directions are given in magnetic degrees.
- **Explanation**
  [Speaker 1] explained that wind direction in METAR or written reports is always in true degrees, while ATC or spoken instructions use magnetic degrees. The mnemonic 'T for text = true, M for mouth = magnetic' helps remember this. Runway directions are also given in magnetic degrees, which is why ATC uses magnetic.
- **Examples**
  > If wind direction is given in text, it is true. If given verbally, it is magnetic.

  - Text (T) = True.
  - Mouth (M) = Magnetic.
- **Considerations**
- Always check the source of wind direction information (text or verbal) before using it for navigation.
- Remember that runway headings are magnetic.
- **Special Circumstances**
- If unsure whether wind direction is true or magnetic, clarify the source (text or ATC) before proceeding.

Track Made Good

> Track made good is the actual path of the aircraft over the ground, considering wind effects. It is used to determine the actual wind velocity when combined with airspeed, heading, and ground speed.

- **Keypoints**
  - Track made good is the actual ground track of the airplane.
  - Given airspeed, heading, ground speed, and track made good, wind velocity can be calculated.

- **Explanation**
  [Speaker 1] described that track made good is the actual track of the airplane over the ground. By knowing the airspeed, heading, ground speed, and track made good, it is possible to calculate the actual wind velocity.
- **Considerations**
- Ensure all relevant data (airspeed, heading, ground speed, track) are accurate before calculating wind velocity.

Wind-Up and Wind-Down Methods (CRP-5)

> Two methods for calculating wind velocity and direction using a navigation computer (CRP-5): wind-up and wind-down. The choice of method depends on which values are known (track or heading).

- **Keypoints**
  - Wind-up method: use track for alignment.
  - Wind-down method: use heading for alignment.
  - Align the circle with true airspeed.
  - Set either track or heading as appropriate.
  - Measure drift and ground speed to determine wind velocity and direction.
- **Explanation**
  [Speaker 1] demonstrated both wind-up and wind-down methods. For wind-down, align the circle with true airspeed, set heading, measure drift at ground speed, rotate the disk, and read wind direction and speed. For wind-up, use track instead of heading.
- **Examples**
  > Given true airspeed 110 knots, ground speed 135, heading 230 true, track 240 true. Find wind velocity and direction.

  - Align circle with 110 (true airspeed).
  - For wind-down: set heading to 230.
  - Drift is 10 degrees (track 240 - heading 230).
  - At ground speed 135, measure 10 degrees drift to the right.
  - Rotate disk until dot is below the blue circle.
  - Read wind direction (e.g., 95 degrees) and speed (subtract 78 from 110 to get 32 knots).
- **Considerations**
- Choose the correct method (wind-up or wind-down) based on available data.
- Double-check alignment and measurements for accuracy.
- **Special Circumstances**

- If using the wrong reference (track instead of heading or vice versa), recalculate using the correct method.

Compass Heading Calculation

> The process of determining the compass heading by applying variation and deviation to the true heading, using the CDMVT formula. This involves understanding the effects of magnetic variation (east or west) and deviation (instrument error) on the aircraft's heading.

- **Keypoints**
  - True heading is adjusted by variation and deviation to obtain magnetic and compass headings.
  - East variation is subtracted, west variation is added.
  - Deviation is applied after variation.
  - CDMVT formula: Compass = Deviation + Magnetic = Variation + True.
- **Explanation**
  In the class, [Speaker 1] explains that to find the compass heading, you start with the true heading, apply the variation (east is minus, west is plus), then apply the deviation (west is plus, east is minus). For example, with a true heading of 143, variation 6 east, and deviation 2 west: 143 - 6 = 137, then 137 + 2 = 139. The process is repeated for different scenarios, and students are asked to calculate and verify the results.
- **Examples**
  > Given: True heading = 143, Variation = 6 east, Deviation = 2 west. Calculation: 143 - 6 = 137 (magnetic heading), 137 + 2 = 139 (compass heading).

  - Start with the true heading: 143.
  - Apply variation: 6 east means subtract 6, so 143 - 6 = 137.
  - Apply deviation: 2 west means add 2, so 137 + 2 = 139.
  - Final compass heading is 139.
- **Considerations**
- Always check the sign (plus or minus) for variation and deviation.
- Be precise with degree values, as options may differ by only 1 degree.
- **Special Circumstances**
- If encountering a scenario where variation or deviation is not provided, clarify with the instructor or refer to the navigation chart.

Difference Between Heading and Track

> Heading is the direction in which the aircraft's nose is pointed, while track is the actual path over the ground. Wind correction angle is applied to maintain the

> desired track.

- **Keypoints**
  - Heading is affected by wind; track is the intended path.
  - Wind correction angle is added or subtracted to maintain track.
  - Drift occurs when wind pushes the aircraft off the intended track.
- **Explanation**
  [Speaker 1] explains that heading is what you fly, and track is where you want to go. If you are drifting to the left, you must turn right by the drift angle to maintain the track. The calculation involves determining the drift and adjusting the heading accordingly.
- **Examples**
  > Given: Track = 136 true, drift to the left by 4 degrees. Heading = 136 + 4 = 140.

  - Identify the drift direction (left).
  - Add the drift angle to the track to get the heading: 136 + 4 = 140.
  - Use this heading to maintain the desired track.
- **Considerations**
- Always determine the direction of drift before adjusting heading.
- Use precise values for drift angles.
- **Special Circumstances**
- If wind changes during flight, recalculate drift and adjust heading accordingly.

Wind Correction and Ground Speed Calculation

> Calculating the effect of wind on aircraft heading and ground speed, using true airspeed, wind direction, and wind speed. The CRP5 navigation computer is used for these calculations.

- **Keypoints**
  - True airspeed, wind direction, and wind speed are required inputs.
  - Wind correction angle is determined using the navigation computer.
  - Ground speed is affected by the wind's headwind or tailwind component.
- **Explanation**
  [Speaker 1] demonstrates using the CRP5 to set true airspeed, wind direction, and wind speed. The drift is measured, and the heading is adjusted accordingly. Ground speed is read from the computer after setting the drift angle.
- **Examples**
  > Given: True airspeed = 110 knots, wind direction = 170, wind speed = 10 knots, track = 025. Drift is 3 degrees left, so heading = 025 + 3 = 028. Variation is 4 west, so magnetic heading = 028 + 4 = 032.

  - Set true airspeed on the navigation computer.
  - Set wind direction and speed.
  - Measure drift (3 degrees left).
  - Adjust heading: 025 + 3 = 028.
  - Apply variation: 028 + 4 = 032 (magnetic heading).
- **Considerations**
- Ensure correct input of wind direction and speed.
- Be accurate with drift measurement for precise heading.
- **Special Circumstances**
- If wind speed changes between sectors, recalculate for each sector.

Sector Navigation and Heading Calculation

> Calculating magnetic headings for multiple sectors using given tracks, wind conditions, and variations. Each sector may have different wind speeds and tracks.

- **Keypoints**
  - Each sector requires separate calculation based on its conditions.
  - Wind speed and direction may change between sectors.
  - Variation must be applied to each calculated heading.
- **Explanation**
  [Speaker 1] leads the class through calculating headings for three sectors. For each, students set the true airspeed, wind direction, and wind speed, measure drift, adjust heading, and apply variation to find the magnetic heading.
- **Examples**
  > Sector 1: Track = 025, drift = 3 left, heading = 028, variation = 4 west, magnetic heading = 032. Sector 2: Track = 043, drift = 4 left, heading = 047, variation = 4 west, magnetic heading = 051. Sector 3: Track = 055, drift = 8 left, heading = 063, variation = 4 west, magnetic heading = 067.

  - For each sector, set the track and wind conditions.
  - Measure drift and adjust heading.
  - Apply variation to get magnetic heading.
- **Considerations**
- Recalculate for each sector if wind conditions change.
- Be precise with degree values, as options may be close.
- **Special Circumstances**
- If sector boundaries are unclear, clarify with the instructor.

Determining Wind Velocity from Heading, Track, and Ground Speed

> Given the aircraft's heading, track, and ground speed, the wind velocity can be determined using the navigation computer and vector analysis.

- **Keypoints**
  - Heading and track difference gives drift angle.
  - Ground speed and drift are used to find wind speed and direction.
  - CRP5 navigation computer is used for calculation.
- **Explanation**
  [Speaker 1] explains that if the heading is less than the track, the aircraft is drifting to the right, indicating wind from the left. The difference in degrees is the drift angle. Using ground speed and drift, the wind vector can be determined.
- **Examples**
  > Given: Track = 264, Heading = 252, Ground speed = 102 knots. Drift = 12 degrees right. Use navigation computer to set ground speed and drift, then read wind direction and speed.

  - Calculate drift: 264 - 252 = 12 degrees.
  - Set ground speed and drift on navigation computer.
  - Read wind direction and speed from the computer.
- **Considerations**
- Ensure correct identification of drift direction.
- Use accurate values for heading, track, and ground speed.
- **Special Circumstances**
- If heading and track are equal, wind is directly ahead or behind.

Calculation of Magnetic Heading

> The process of converting true track to magnetic track using variation, and then adjusting for wind drift to determine the magnetic heading required to maintain a desired track.

- **Keypoints**
  - True track is given (e.g., 186).
  - Variation is applied (e.g., 2 degrees west: add to true track).
  - Wind correction is determined by measuring drift (e.g., 3 degrees left drift).
  - Final heading is magnetic track plus or minus drift.
- **Explanation**
  Given a true track of 186 and a variation of 2 degrees west, the magnetic track is 188. If wind causes a 3-degree left drift, add 3 to the magnetic track to get a heading of 191.
- **Examples**

> True airspeed is 98, wind is 325 at 10, variation is 2 degrees west. Find magnetic heading for a true track of 186.

- Convert true track (186) to magnetic track: 186 + 2 = 188.
- Determine wind drift: 3 degrees left.
- Adjust heading: 188 + 3 = 191.
- Final magnetic heading is 191.

- **Considerations**
- Always use the correct sign for variation (east subtract, west add).
- Wind drift direction must be correctly identified (left or right).
- **Special Circumstances**
- If wind drift is to the left, add drift to magnetic track; if to the right, subtract.

Airspeed Types and Corrections

> Understanding the differences between indicated airspeed (IAS), calibrated airspeed (CAS), equivalent airspeed (EAS), and true airspeed (TAS), and the corrections required for each.

- **Keypoints**
  - IAS is what is read on the instrument.
  - CAS is IAS corrected for instrument and position error.
  - EAS is CAS corrected for compressibility error.
  - TAS is EAS corrected for altitude and temperature.
- **Explanation**
  Instrument error arises from manufacturing inaccuracies. Position error is due to disturbed airflow into the pitot tube, especially at high angles of attack or during maneuvers. Corrections are applied stepwise to reach TAS.
- **Examples**
  > Cruising at 7,000 feet, temperature 0, CAS is 100 knots. Align 7 with 0 on CRP-5, read TAS as 114.

  - Set pressure altitude (7,000) and temperature (0) on CRP-5.
  - Read TAS corresponding to CAS (100 knots): TAS = 114 knots.
- **Considerations**
- Use pressure altitude (1013 hPa) for TAS calculations.
- Correct for local QNH if given.
- **Special Circumstances**
- If QNH is not 1013, convert altitude to pressure altitude before calculation.

Instrument and Position Error

> Instrument error is due to manufacturing inaccuracies; position error is caused by disturbed airflow into the pitot tube, especially at high angles of attack, during maneuvers, or when using flaps/slats.

- **Keypoints**
  - Instrument error: inherent inaccuracies in the instrument.
  - Position error: airflow not entering pitot tube directly.
  - Most significant at high angle of attack or during maneuvers.
- **Explanation**
  ES (EAS) is corrected for both instrument and position error to obtain CAS.
- **Considerations**
- Check for significant position error during non-cruise flight phases.
- **Special Circumstances**
- If airflow is disturbed (e.g., side slipping), expect higher position error.

Pressure Altitude and QNH

> Pressure altitude is the altitude with 1013 hPa set on the altimeter. For TAS calculations, always use pressure altitude, not indicated altitude.

- **Keypoints**
  - Set altimeter to 1013 hPa to read pressure altitude.
  - If local QNH is given, convert indicated altitude to pressure altitude.
- **Explanation**
  For phase 1, examples use pressure altitude directly. For phase 2, conversion from QNH to pressure altitude is required.
- **Considerations**
- Always check which altitude reference is required for the calculation.
- **Special Circumstances**
- If given local QNH, adjust altimeter setting before calculation.

Corrected Outside Air Temperature (OAT)

> OAT must be corrected for temperature rise due to friction between the aircraft and air, but this is only significant above 150 knots.

- **Keypoints**
  - Below 150 knots, friction temperature rise is negligible.
  - Above 150 knots, apply correction as per aircraft manual.
- **Explanation**
  For most training aircraft, OAT correction is not significant.
- **Considerations**

- Check aircraft manual for correction tables if flying fast jets.
- **Special Circumstances**
- If TAS exceeds 150 knots, apply OAT correction.

Compressibility Correction

> At speeds above 250 knots, compressibility correction must be applied to airspeed readings, especially for high-speed jets.

- **Keypoints**
  - Compressibility error is not significant below 300 knots.
  - Use CRP-5 table for correction in phase 2 training.
- **Explanation**
  For phase 1, ignore compressibility correction. For phase 2, apply as per CRP-5.
- **Considerations**
- Apply only when indicated by aircraft speed and phase of training.
- **Special Circumstances**
- If flying above 250 knots, check for required compressibility correction.

Time, Speed, and Distance Calculations

> Calculating time, speed, and distance is fundamental for navigation. Use ground speed to determine how many nautical miles are covered per minute.

- **Keypoints**
  - Ground speed of 90 knots = 1.5 NM per minute.
  - 60 knots = 1 NM per minute; 120 knots = 2 NM per minute.
  - Distance = speed × time; Time = distance ÷ speed.
- **Explanation**
  Use simple math or a calculator for precise results. For example, 34 NM at 97 knots: 34 ÷ 97 = 0.35 hours = 21 minutes.
- **Examples**
  > Overhead point alpha at 13:14, distance to Bravo is 47 NM. At 13:29, 26 NM from alpha. Find ETA at Bravo.

  - Time from alpha to 26 NM point: 15 minutes.
  - Speed: 26 NM ÷ 15 min × 60 = 104 knots.
  - Distance remaining: 47 - 26 = 21 NM.
  - Time to Bravo: 21 ÷ 104 × 60 = 12 minutes.
  - ETA: 13:29 + 12 min = 13:41.
- **Considerations**
- Use calculator for accuracy.

- Remember conversion factors (knots to NM/min).
- **Special Circumstances**
- If instructed not to use a calculator, use mental math or estimation techniques.

Fuel Consumption and Endurance Calculations

> Calculating required fuel for a flight, including allowances for taxi and power checks, and determining airborne endurance based on available fuel and consumption rate.

- **Keypoints**
  - Total fuel required = (flight time × consumption rate) + taxi allowance.
  - Endurance = (total fuel - taxi allowance) ÷ consumption rate.
- **Explanation**
  For example, 2 hours 37 minutes at 5 US gallons/hour, plus 1 gallon for taxi: (2.62 × 5) + 1 = 14.1 gallons.
- **Examples**
  > Flight time 2 hours 37 minutes, consumption 5 US gallons/hour, 1 gallon for taxi.

  - Convert 2 hours 37 minutes to hours: 2.62 hours.
  - Multiply by 5: 13.1 gallons.
  - Add 1 gallon: 14.1 gallons required.

  > Total fuel 33 gallons, consumption 7 gallons/hour, 1 gallon for taxi.

  - Subtract taxi fuel: 33 - 1 = 32 gallons.
  - Divide by consumption: 32 ÷ 7 = 4.57 hours (4 hours 34 minutes).
- **Considerations**
- Always include taxi and power check allowances.
- Convert minutes to hours accurately.
- **Special Circumstances**
- If fuel is given in liters, convert to gallons if necessary.

Calculation of True Airspeed (TAS) from Indicated Airspeed (IAS) and Calibrated Airspeed (CAS)

> The process of determining the true airspeed of an aircraft by using indicated airspeed, calibrated airspeed, altitude, and temperature, typically with the aid of a flight computer. This involves aligning specific values on the inner and outer scales and applying corrections for altitude and temperature.

- **Keypoints**
  - Align the appropriate altitude and temperature values on the flight computer.

    - Use the inner and outer scales to find the corresponding true airspeed for a given calibrated airspeed.
    - Apply corrections for altitude (e.g., 7,000 feet, 2,500 feet, flight level 5-0) and temperature (e.g., 0°C, +10°C).
    - Read the resulting true airspeed directly from the flight computer after proper alignment.
- **Explanation**
  During the session, [Speaker 1] and others guide the group through several examples: For a cruising altitude of 7,000 feet, outside temperature of zero, and a CAS of 120, the group aligns 7,000 with 0 on the flight computer, then finds the CAS of 120, resulting in a TAS of 133 or 134. For an altitude of 2,500 feet and temperature of 0°C, the TAS is found to be 108. For flight level 5-0, indicated airspeed of 104 knots, and outside air temperature of +10°C, the group discusses the process and arrives at a TAS of 110.
- **Examples**
  > Given: Cruising altitude 7,000 feet, outside temperature 0°C, CAS 120. The group aligns 7,000 with 0 on the flight computer, then finds the CAS of 120, resulting in a TAS of 133 or 134.

    - Align 7,000 feet with 0°C on the flight computer.
    - Locate CAS of 120 on the scale.
    - Read the corresponding TAS, which is 133 or 134.
  > Given: Altitude 2,500 feet, temperature 0°C. The group finds the TAS to be 108.

    - Align 2,500 feet with 0°C on the flight computer.
    - Find the indicated airspeed value.
    - Read the TAS as 108.
  > Given: Flight level 5-0, indicated airspeed 104 knots, outside air temperature +10°C. The group discusses the process and arrives at a TAS of 110.

    - Align flight level 5-0 with +10°C on the flight computer.
    - Find the IAS of 104 knots.
    - Read the TAS as 110.
- **Considerations**
- Ensure precise alignment of scales on the flight computer.
- Double-check readings to avoid errors.
- Practice repeatedly to gain proficiency.
- **Special Circumstances**
- If the temperature is negative or significantly different from standard, ensure the correct scale is used for correction.
- If the flight computer is moved accidentally, reset and realign before proceeding.

Time-Distance-Speed Calculations in Aviation

> Solving for the time required to cover a given distance at a specified ground speed using basic aviation formulas and the flight computer.

- **Keypoints**
  - Use the formula: Time = Distance / Speed.
  - Set up the flight computer to align the ground speed with the distance to find the time.
  - Ensure units are consistent (e.g., knots for speed, nautical miles for distance, minutes for time).
- **Explanation**
  [Speaker 1] asks: 'Travelling over ground speed of 135 knots, how long will it take you to cover distance of 35 nautical miles?' The answer given is 15.5 minutes.
- **Examples**
  > Given: Ground speed 135 knots, distance 35 nautical miles. The group calculates the time required as 15.5 minutes.

  - Use the formula: Time = Distance / Speed.
  - Time = 35 / 135 = 0.259 hours.
  - Convert 0.259 hours to minutes: 0.259 x 60 = 15.5 minutes.
- **Considerations**
- Always check that the units for speed and distance are compatible.
- Use the flight computer for quick and accurate calculations.
- **Special Circumstances**
- If the ground speed changes during flight, recalculate time for each segment.

Use of Flight Computer (E6B or Similar) for Airspeed and Navigation Calculations

> The flight computer is a mechanical device used to solve various aviation-related calculations, including airspeed conversions, time-distance-speed problems, and corrections for altitude and temperature.

- **Keypoints**
  - Align the correct values on the inner and outer scales as per the calculation requirement.
  - Use the red line or indicator for precise readings.
  - Understand the function of each scale (e.g., indicated airspeed, true airspeed, temperature, altitude).
- **Explanation**
  Throughout the session, multiple speakers discuss aligning scales, moving the inner

circle, and using the red line for precision. They emphasize the importance of correct setup and reading for accurate results.

- **Examples**

  > Instruction: 'Go to airspeed section, and align 2 with 20, align 2 with 20, and then go to the 11, in the inner scale, where it's a cos, and then the read on the outer scale, 1, 1, 5.'

  - Go to the airspeed section of the flight computer.
  - Align 2 with 20 on the scales.
  - Go to 11 on the inner scale (possibly referring to a cosine correction).
  - Read the result on the outer scale, which is 1, 1, 5.
- **Considerations**
- Do not move the arrow or indicator unintentionally during calculations.
- If the device is reset or moved, start the alignment process again.
- **Special Circumstances**
- If unsure about a step, repeat the process or consult with an instructor.

Assignments & Suggestions

- Practice converting between true, magnetic, and compass headings using variation and deviation.
- Practice measuring distances and directions on maps using plotters and the thumb rule.
- Familiarize yourself with map legends and symbols, especially for new maps.
- Read the lecture and practice with the map in preparation for the SOP course.
- Practice calculating heading and ground speed using wind data and airspeed, as demonstrated in the class.
- Review and use the E6BX website for flight planning calculations.
- Compare answers with classmates for the example problem provided.
- Practice the calculation of true airspeed using the flight computer for various combinations of altitude, temperature, and calibrated airspeed.
- Solve time-distance-speed problems using the flight computer.
- Prepare for the exam by ensuring proficiency in airspeed and navigation calculations.