04-06-2025 GNav Lecture 4 + Revision

> Date & Time: 2025-06-04 16:57:26
> Location: [Insert Location]
> [Insert Title]
> `dead reckoning navigation` `map reading` `fuel calculation`

Theme

This lecture provides a comprehensive overview of dead reckoning navigation, map reading, and fuel planning for pilots. Key topics include navigation techniques without avionics, landmark identification, calculation of headings and ground speed, fuel requirements, and regulatory compliance. Practical examples and calculation methods are discussed to prepare students for navigation exercises and exams, emphasizing safety, accuracy, and adherence to aviation standards.

Takeaways

1. Dead reckoning navigation
2. Requirements for lesson and test completion
3. Progress tests
4. Calculation of headings, ground speed, and time
5. Importance of accurate wind speed and direction forecasting
6. Historical context of dead reckoning
7. Essential tools for dead reckoning
8. Example calculation: Folkestone to Cap Grisnes
9. Minimum sector altitude and flight level
10. Calculation of time to FIR boundary

Highlights

- `"If nothing else, dead reckoning would always work even if every item of avionics in the aircraft has ceased to function."-- Speaker 1`
- `"Make the assumption that each landmark has at least three unique characteristics depicted on the map."-- Speaker 1`
- `"By staying in the VFC, the pilot can still control and navigate the aircraft whilst avoiding hazards, such as high terrain and`

`obstructions."-- Speaker 1`

- `"Aviate, navigate, communicate."-- Speaker 1`
- `"For 1 degree track error, I will be 1 nautical mile away from the track in 60 nautical miles."-- Speaker 1`
- `"You have to feel what I feel, come on."-- [Speaker 1]`
- `"It's fun until you can't get off the runway."-- Speaker 5`

Chapters & Topics

Dead Reckoning Navigation

> Dead reckoning is a traditional navigation method used for thousands of years, relying on calculations of heading, speed, and time to estimate position without the use of modern electronic aids. It is based on triangle velocities and requires accurate forecasting of wind speed and direction, as well as precise calculations and execution of headings and airspeeds.

- **Keypoints**
  - Dead reckoning is based on triangle velocities and calculations.
  - Requires calculation of headings, ground speed, and time using only basic tools: calculator, plotter, map, watch, compass, and airspeed indicator.
  - Accuracy depends on the accuracy of wind speed and direction forecasts, and the precision of calculations and flying.
  - Works even if all avionics fail.
  - Should always start from a known point (departure airfield, ground point, coastline, or terminal).
  - Error increases with distance from the known point, especially if weather forecasts are inaccurate.
  - Early aviation pioneers used dead reckoning for long-distance flights.
  - Best to confirm dead reckoning results with other methods when possible.
- **Explanation**
  Dead reckoning involves determining your position by starting from a known point and using calculated headings, ground speed, and elapsed time to estimate your current position. The process requires checking weather forecasts for wind speed and direction, calculating the necessary heading to compensate for wind, determining ground speed, and then using these to estimate the time required to reach waypoints or destinations. The method is reliable as long as the initial data and calculations are accurate, but errors can accumulate over long distances or with inaccurate forecasts.
- **Examples**

> A map is used to plot a course from Folkestone to Cap Grisnes. The true direction is 130, variation is 2 west, true airspeed is 75 knots, leg distance is 19.5 nautical miles, wind speed and direction is 24010. The minimum sector altitude is 1900 feet, flight level is 3500 feet. The calculated heading is 137 magnetic, ground speed is 77 knots, and the time to cross the FIR boundary (13 nautical miles from Folkestone) is 10 minutes.

  - Plot the course on the map from Folkestone to Cap Grisnes.
  - Determine the true direction (130), apply variation (2 west) to get magnetic heading.
  - Use true airspeed (75 knots) and wind speed/direction (24010) to calculate ground speed (77 knots) and wind correction angle.
  - Measure the distance to the FIR boundary (13 nautical miles).
  - Calculate time to boundary: 13 nautical miles divided by 77 knots = 10 minutes.
  - After takeoff, fly heading 139 magnetic for 10 minutes to cross the boundary.
- **Considerations**
- Always start dead reckoning from a known point.
- Confirm dead reckoning results with other navigation methods when possible.
- Be aware that errors increase with distance from the starting point, especially if weather forecasts are inaccurate.
- Use only basic tools: watch, compass, airspeed indicator, calculator, plotter, and map.
- **Special Circumstances**
- If all avionics fail, rely on dead reckoning using basic tools.
- If weather forecasts are inaccurate, expect greater errors in position estimation and adjust accordingly.

Map Reading and Landmark Identification

> Map reading is essential for navigation, involving the identification of ground features and their representation on maps. Pilots must relate actual ground features to map symbols to establish their position and select appropriate waypoints.

- **Keypoints**
  - Ability to relate ground features to their depiction on the map is crucial.
  - Map symbols are generally intuitive and explained in the map key.
  - Selection of waypoints should consider both general location (major features nearby) and local area (smaller features around the landmark).
  - Landmarks should be chosen for visibility and ease of identification.
  - Relating the position of smaller features (towns, rivers, roads, airfields) to the landmark helps confirm location.

- **Explanation**
  Pilots must learn to identify landmarks from the air and match them to their map representations. This involves understanding map symbols and selecting waypoints that are easily visible and have distinctive features. The process includes considering both the general location (e.g., a small town near a prominent mountain) and the local area (e.g., nearby rivers, roads, or airfields) to ensure accurate identification.
- **Examples**
  > During local navigation in Burgos two years ago, the pilot used the water reservoir Aguilar de Campo as a reference point. Below the reservoir, there was a small grass runway with no aircraft, serving as a free airstream. The reservoir and nearby features helped in identifying the location.

  - Identify the large water reservoir (Aguilar de Campo) on the map and from the air.
  - Note the presence of a small grass runway below the reservoir.
  - Use the reservoir as a prominent landmark and the runway as a secondary feature to confirm position.
- **Considerations**
- Choose landmarks with major topographical features nearby for easier identification.
- Use the map key to understand symbols and avoid guessing.
- Relate the positions of smaller features to the main landmark for confirmation.
- **Special Circumstances**
- If a chosen landmark is hard to identify, use nearby prominent features (e.g., a mountain near a small town) to assist in location confirmation.

Lesson and Test Completion Requirements

> To complete the course, students must finish 100% of the lessons and pass 100% of the tests. There are progress tests to monitor advancement, and completion may be checked by the instructor or Diego.

- **Keypoints**
  - 100% of lessons must be completed.
  - 100% of tests must be passed.
  - There is at least one progress test, and a second one is also required.
  - Completion may be checked by the instructor and Diego.
- **Explanation**
  Students are required to complete all lessons and tests as part of the course requirements. Progress is monitored through tests, and both the instructor and Diego may verify completion.
- **Considerations**

- Ensure all lessons and tests are completed and passed before the end of the course.
- Monitor progress using the provided tests.

Selection of Landmarks for Navigation

> Selecting prominent and easily identifiable landmarks is crucial for effective navigation. Landmarks should have at least three unique characteristics that can be cross-checked on the map and in reality. Major topographical features such as coastlines, high ground, and cities are excellent references, while line features like motorways, railway lines, major rivers, and canals are best for fixing precise positions. Minor features, such as small villages, woodland, or small lakes, can be unreliable, especially if their shapes are not accurately depicted on the map or if they change seasonally.

- **Keypoints**
  - Prominent landmarks should be chosen for navigation.
  - Each landmark should have at least three unique characteristics.
  - Major features (coastlines, high ground, cities) are reliable.
  - Line features (motorways, railways, rivers, canals) are best for precise fixes.
  - Minor features and seasonal changes can make identification unreliable.
- **Explanation**
  When planning a route, select landmarks that are easily visible from the air and have distinct features. For example, a town at the intersection of a motorway, railway, and river is easier to identify. Always verify at least three unique characteristics of a landmark to avoid misidentification. Avoid using features that are not well defined or that change with the seasons.
- **Examples**
  > On the way from Google to Victoria, Pancorvo is a small town situated between two mountains, forming a V-shaped valley visible from 20 or 30 nautical miles from Burgos.

  - The V-shape is a unique characteristic visible from a distance.
  - This makes Pancorvo an excellent landmark for navigation.
- **Considerations**
- Grass airfields and private strips may be hard to spot, especially in summer.
- Disused airfields should only be used if well defined.
- Consult instructors or experienced pilots for landmark selection.
- **Special Circumstances**
- If encountering seasonal changes (e.g., trees by rivers in summer), adjust landmark selection accordingly.

- If a landmark is not visible due to weather or altitude, select a temporary reference point ahead.

Three-Feature Principle for Landmark Identification

> To avoid misidentifying landmarks, always ensure that each selected landmark has at least three unique characteristics that can be cross-checked between the map and the real world.

- **Keypoints**
  - Reduces risk of navigational errors.
  - Requires conscious verification of features.
  - Helps eliminate the error of making ground features fit the map.
- **Explanation**
  When you think you have identified a landmark, refer to the map and check for three unique features (e.g., a town, a river, a railway crossing). Only confirm the landmark if all three are present.
- **Considerations**
- Do not force ground features to fit the map.
- Always verify three characteristics before confirming a landmark.
- **Special Circumstances**
- If only one or two features are visible, do not confirm the landmark; continue searching or use another reference.

Dead Reckoning and Map Reading

> Dead reckoning and map reading are two fundamental navigation methods. Dead reckoning relies on accurate flight planning, maintaining heading and speed, and correct wind forecasts. Map reading involves knowing your position at all times by referencing ground features and using time markers.

- **Keypoints**
  - Dead reckoning is dependent on accurate planning and wind forecasts.
  - Map reading requires constant awareness of position using ground features.
  - Both methods have drawbacks if used in isolation.
- **Explanation**
  Use dead reckoning to estimate position based on heading, speed, and time. Use map reading to confirm position by identifying ground features. Combine both methods for best results.
- **Considerations**
- If wind conditions differ from forecast, recalculate ground speed and time for each leg.

- Use a timer and plotter to estimate position if features are not visible.
- **Special Circumstances**
- If flying over featureless terrain or water, rely more on dead reckoning and time markers.

Time, Turn, Talk, Task Procedure

> A systematic procedure for managing workload during navigation: Time (record actual time of arrival at waypoint), Turn (change heading to next leg), Talk (transmit position report if necessary), Task (recalculate ETA and perform other tasks).

- **Keypoints**
  - Ensures all navigation tasks are completed in sequence.
  - Helps maintain situational awareness and workload management.
  - Reduces risk of missing important steps.
- **Explanation**
  At each waypoint, immediately record the time, turn to the new heading, transmit position if required, and recalculate ETA for the next waypoint. Perform any other necessary tasks such as changing altitude or frequency.
- **Considerations**
- Always follow the sequence to avoid missing steps.
- If a landmark is not visible, select a temporary reference point.
- **Special Circumstances**
- If unable to transmit position report, proceed with other steps and report when possible.

Maximum Distance Between Waypoints

> The maximum distance allowed between waypoints in navigation planning is 20 nautical miles, according to SOP. If the distance between two selected waypoints exceeds 20 nautical miles, an additional waypoint must be inserted.

- **Keypoints**
  - Ensures regular position checks and reduces risk of getting lost.
  - Applies to all navigation planning.
- **Explanation**
  When planning a route, measure the distance between each waypoint. If any leg exceeds 20 nautical miles, select an additional waypoint between them.
- **Considerations**
- Always check distances during flight planning.
- Do not exceed 20 nautical miles between waypoints.
- **Special Circumstances**

- If no suitable landmark exists within 20 nautical miles, select the best available feature or use a temporary reference.

Navigation Minimum Levels and Typical Altitudes

> The navigation minimum level is usually 1,000 feet AGL, but typical cruising altitudes are 2,000 to 3,000 feet AGL. For Burgos, typical altitudes are 5,500 to 6,500 feet. Exceptions apply when entering or leaving controlled airspace, such as maintaining 5,000 feet for departure and 4,500 feet for return at Burgos.

- **Keypoints**
  - Minimum level: 1,000 feet AGL (not usual in civil flight).
  - Typical level: 2,000–3,000 feet AGL.
  - Burgos: 5,500–6,500 feet.
  - Special procedures for entry/exit in controlled airspace.
- **Explanation**
  Maintain the recommended altitude for your route unless instructed otherwise by ATC or due to airspace restrictions. Always prioritize maintaining VFR.
- **Considerations**
- Do not descend below minimum levels unless necessary for VFR.
- Follow published procedures for entry and exit in controlled airspace.
- **Special Circumstances**
- If instructed by ATC to descend, comply while maintaining VFR.
- If forced to descend due to weather, prioritize visual conditions.

Maintaining Visual Flight Conditions (VFR)

> Maintaining VFR is an absolute priority for non-instrument rated pilots. Never enter clouds or IMC. Staying in VFR allows the pilot to control and navigate the aircraft while avoiding hazards.

- **Keypoints**
  - Never enter clouds or IMC.
  - VFR allows avoidance of terrain and obstructions.
  - Past accidents have occurred due to entering IMC.
- **Explanation**
  Always ensure you have sufficient visibility and remain clear of clouds. If conditions deteriorate, descend or alter course to maintain VFR.
- **Considerations**
- Monitor weather and visibility at all times.
- Do not attempt to continue in IMC.
- **Special Circumstances**

- If inadvertently entering IMC, immediately take action to regain VFR (descend, turn back, etc.).

Navigation at Low vs. High Altitude

> At low altitude, it is harder to identify the outlines of towns, lakes, and other features due to a shallower viewing angle and possible terrain masking. At higher altitudes, features are easier to identify and are visible for longer.

- **Keypoints**
  - Low altitude: harder to identify features, shorter visibility window.
  - High altitude: easier identification, longer visibility.
- **Explanation**
  Climb to a higher altitude if possible to improve visibility of landmarks. At low altitude, be aware that features may be hidden by terrain or woodland.
- **Considerations**
- Choose altitude based on safety, visibility, and airspace requirements.
- **Special Circumstances**
- If forced to fly low, increase vigilance and use more frequent position checks.

Handling Featureless Terrain

> When flying over featureless terrain (no lakes, towns, roads, or railways), integrate dead reckoning and map reading. Use timers and 2-minute dashes to estimate position. If possible, plan the route to follow a prominent line feature, even if it increases distance.

- **Keypoints**
  - Use time and distance calculations to estimate position.
  - Plan to follow any available prominent feature.
  - Use GPS or call ATC if lost.
- **Explanation**
  If no features are visible, rely on your timer and plotter to estimate distance traveled. Mark 2-minute intervals on your map to track progress. Use GPS or contact ATC if necessary.
- **Considerations**
- Always have a backup plan (GPS, radio contact) in case of disorientation.
- **Special Circumstances**
- If lost, use GPS, call ATC, or use your phone for navigation assistance.

Transit Technique in Navigation

> The transit technique is a navigation method used in aviation, especially useful when flying at minimum level or over featureless terrain. It involves identifying and aligning multiple landmarks that are in a straight line, allowing the pilot to navigate towards a destination, such as a small grass airstrip, by following these aligned reference points.

- **Keypoints**
  - Transit technique helps ensure accurate navigation when prominent landmarks are absent.
  - Landmarks such as a TV mast, lake, and airstrip can be aligned on a map and used sequentially.
  - The technique is applicable both in maritime and aviation contexts.
  - It is especially useful for finding small or hidden airfields among similar terrain features.
- **Explanation**
  The instructor explains that when flying over areas with few distinguishing features, pilots can use the transit technique by identifying a series of landmarks that are aligned. For example, if a TV mast, a lake, and an airstrip are on the same line, the pilot can fly towards the TV mast, then as the lake comes into view, continue towards it, and finally reach the airstrip. This method provides a reliable way to navigate when direct visual identification of the destination is difficult.
- **Examples**
  > A pilot is flying to a small grass airfield surrounded by similar grass fields. There is no prominent landmark next to the airfield. On the map, the pilot notes that a tall TV mast, a lake, and the airstrip are aligned. The pilot flies towards the TV mast, and upon reaching it, starts to see the lake, then continues and eventually arrives at the airstrip.

  - Identify the TV mast as the first visible landmark.
  - Fly towards the TV mast, knowing the lake and airstrip are aligned beyond it.
  - Upon reaching the TV mast, look for the lake to appear in view.
  - Continue flying in the same direction, using the lake as the next reference.
  - Eventually, the airstrip comes into view, completing the navigation sequence.
- **Considerations**
- Select reference waypoints that are clearly aligned on the map.
- Ensure that the chosen landmarks are visible and distinguishable from the air.
- Be aware that some landmarks may be hidden until passing a previous reference point.
- **Special Circumstances**
- If encountering featureless terrain with no prominent landmarks, use the transit technique by aligning multiple smaller features that can be sequentially identified.

Order of Priorities in Flight

> The principal priority when in the air is to follow the sequence: Aviate, Navigate, Communicate. This means the pilot should first ensure the aircraft is being flown safely, then focus on navigation, and finally communicate as needed.

- **Keypoints**
  - Aviate: Maintain control of the aircraft at all times.
  - Navigate: Ensure the aircraft is on the correct course.
  - Communicate: Exchange necessary information with air traffic control or others.
- **Explanation**
  During the quiz, the instructor emphasizes that the correct order of priorities is Aviate, Navigate, Communicate. This is a fundamental principle in aviation safety and decision-making.
- **Considerations**
- Always maintain control of the aircraft before addressing navigation or communication tasks.
- **Special Circumstances**
- If encountering an emergency, prioritize flying the aircraft before attempting to navigate or communicate.

Wind Correction and Magnetic Heading Calculation

> Calculating the correct magnetic heading to maintain a desired track involves considering wind speed, wind direction, and magnetic variation. The process includes determining drift, applying corrections, and adjusting for magnetic variation.

- **Keypoints**
  - Determine wind speed and direction (e.g., 3 to 5 knots).
  - Calculate drift angle (e.g., 3 degrees).
  - Apply drift correction to the intended track (e.g., 186 degrees).
  - Adjust for magnetic variation (e.g., 2 degrees west).
  - Final heading example: 189 or 191 degrees, depending on calculations.
- **Explanation**
  The class discusses a scenario where the tourist speed is 8 knots, wind is 3 to 5 knots, and variation is 2 degrees west. The process involves measuring drift (3 degrees), applying it to the course (e.g., 186 degrees), and then adjusting for magnetic variation to get the final heading (e.g., 189 or 191 degrees).
- **Examples**
  > Given a tourist speed of 8 knots, wind of 3 to 5 knots, and a variation of 2 degrees west, the class calculates the drift as 3 degrees, applies it to the course of 186, and adjusts for variation to get a heading of 189 or 191.

    - Identify wind speed and direction.
    - Calculate drift angle (3 degrees).
    - Add drift to the intended course (186 + 3 = 189).
    - Adjust for magnetic variation (2 degrees west).
    - Final heading is 191 degrees.
- **Considerations**
- Accurately measure wind speed and direction.
- Apply drift correction in the correct direction (left or right).
- Adjust for magnetic variation as specified.
- **Special Circumstances**
- If wind direction or speed changes during flight, recalculate drift and heading as needed.

Turning Point Procedure

> The correct order for turning point procedure in navigation is: Time, Turn, Talk. This sequence ensures that the pilot notes the time, executes the turn, and then communicates or updates navigation information.

- **Keypoints**
    - Time: Note the time at the turning point.
    - Turn: Execute the required turn onto the new heading.
    - Talk: Communicate or update navigation information as needed.
- **Explanation**
  During the quiz, the class is asked to list the correct order of turning point procedure. The answer is 'Time, Turn, Talk,' which is repeated for emphasis.
- **Considerations**
- Follow the correct sequence to avoid confusion or errors during navigation.

Use of Navigation Devices (G1000, CX3)

> Modern navigation devices such as the G1000 and CX3 provide advanced features for pilots, including wind correction, holding patterns, and bearing speed calculations. Some devices may lack certain features like autopilot.

- **Keypoints**
    - G1000 provides comprehensive navigation functions but may not include autopilot.
    - CX3 can perform wind correction and other calculations.
    - Some devices allow input of wind direction and speed for automatic correction.

- **Explanation**
  The discussion covers the use of devices like the G1000 and CX3, with examples of entering wind correction data and using features such as holding patterns. There is also mention of device acquisition and use in testing environments.
- **Examples**
  > A user enters a bearing speed of 50 and a wind direction of 90 with a wind speed of 50 knots into the CX3, which then calculates the correction automatically.

  - Input bearing speed (50).
  - Input wind direction (90).
  - Input wind speed (50 knots).
  - Device calculates and displays the correction.
- **Considerations**
- Understand the capabilities and limitations of each navigation device.
- Ensure devices are properly configured before flight.
- **Special Circumstances**
- If a device lacks a needed feature (e.g., autopilot), plan accordingly and use manual procedures.

Field Planning and Fuel Calculation

> The process of planning a flight includes calculating total fuel, block fuel, contingency, reserve, and alternate fuel. Contingency fuel is 5% of trip fuel, where trip fuel is the fuel required to fly from point A to point B, excluding taxi, reserve, and alternate fuel.

- **Keypoints**
  - Contingency fuel is 5% of trip fuel.
  - Trip fuel is only the fuel from A to B.
  - Calculation requires plotter, map, and ground speed.
  - Exam questions may require calculation of total fuel, block fuel, and breakdowns.
- **Explanation**
  During the exam, students are required to bring a plotter and map to calculate distances. They will be given ground speed and fuel flow to calculate total fuel, including contingency (5% of trip fuel), reserve, and alternate. Taxi fuel is not included in trip fuel.
- **Considerations**
- Always bring plotter and map for calculations.
- Understand the breakdown of fuel types and what is included in trip fuel.

- **Special Circumstances**
- If taxi fuel is not provided, do not include it in trip fuel calculations.

1 in 60 Rule

> A navigation rule stating that for each 1 degree of track error, the aircraft will be 1 nautical mile off track after 60 nautical miles.

- **Keypoints**
  - 1 degree error = 1 nautical mile off after 60 nautical miles.
  - 5 degree error = 5 nautical miles off after 60 nautical miles.
  - 2 degree error = 2 nautical miles off after 60 nautical miles.
  - 10 degree error = 10 nautical miles off after 60 nautical miles.
- **Explanation**
  The rule is used to estimate how far off course an aircraft will be based on its track error over a given distance. For example, a 5 degree error over 60 nautical miles results in being 5 nautical miles off track.
- **Examples**
  > If from departure the starting track error was 1 degree and it's continuing as 1 degree, at 60 nautical miles the aircraft will be 1 nautical mile from the intended track. At 30 nautical miles, it will be 0.5 nautical miles off; at 90 nautical miles, 1.5 nautical miles off.

  - Track error is measured in degrees.
  - Multiply the degree error by the ratio of distance flown to 60 nautical miles to find the off-track distance.
- **Considerations**
- Always assess the degree of track error before making corrections.
- **Special Circumstances**
- If the track error is not constant, recalculate at intervals.

Track Error Angle Calculation

> Track error angle is calculated using the formula: track error angle (degrees) = (distance off-track / distance gone) x 60.

- **Keypoints**
  - Distance off-track is the perpendicular distance from the aircraft to the intended route.
  - Distance gone is the distance flown from the departure point.
  - Multiply the ratio by 60 to get the angle in degrees.

- **Explanation**
  Given an aircraft heading 090, after flying 20 nautical miles, it is 3 nautical miles off track to the north. Track error angle = (3 / 20) x 60 = 9 degrees.
- **Examples**
  > Aircraft heading 090, after 20 nautical miles, is 3 nautical miles off track to the north. Track error angle = (3 / 20) x 60 = 9 degrees.

  - Identify distance off-track (3 nautical miles).
  - Identify distance gone (20 nautical miles).
  - Apply formula: (3 / 20) x 60 = 9 degrees.
- **Considerations**
- Ensure correct identification of distance off-track and distance gone.

Closing Angle Calculation

> Closing angle is used to return to the intended track. The formula is: closing angle (degrees) = (distance off-track / distance to go) x 60.

- **Keypoints**
  - Distance to go is the remaining distance to the destination.
  - Use the same distance off-track as in track error angle.
  - Multiply the ratio by 60 to get the closing angle in degrees.
- **Explanation**
  If the aircraft is 3 nautical miles off track and 45 nautical miles from the destination, closing angle = (3 / 45) x 60 = 4 degrees.
- **Examples**
  > Aircraft is 3 nautical miles off track, 45 nautical miles from destination. Closing angle = (3 / 45) x 60 = 4 degrees.

  - Identify distance off-track (3 nautical miles).
  - Identify distance to go (45 nautical miles).
  - Apply formula: (3 / 45) x 60 = 4 degrees.
- **Considerations**
- Use distance to go, not distance gone, for closing angle.

Determining Corrected Heading

> To correct for off-track error, add the track error angle and closing angle to the current heading. The sum gives the new heading to fly to return to the intended track.

- **Keypoints**
  - Track error angle and closing angle must both be calculated.

    - Add both angles to the current heading.
    - Direction of correction depends on which side of the track the aircraft is on.
- **Explanation**
  If the aircraft is flying 090, with a track error angle of 9 degrees and a closing angle of 4 degrees, the new heading is 090 + 13 = 103. The aircraft should fly 103 to return to the intended track.
- **Examples**
  > Aircraft flying 090, track error angle 9 degrees, closing angle 4 degrees. New heading: 090 + 13 = 103.

    - Calculate track error angle (9 degrees).
    - Calculate closing angle (4 degrees).
    - Add both to current heading (090 + 13 = 103).
- **Considerations**
- Ensure correct direction of correction (left or right of track).
- **Special Circumstances**
- If on the right of the track, subtract the sum from the heading.

Navigation Chart Markings

> Various markings are used on navigation charts to aid in flight planning and navigation, including fan lines, distance markers, time markers, and fraction markings.

- **Keypoints**
    - Fan lines: lines from departure and destination at 5 or 10 degrees to the track.
    - Distance markers: typically every 10 miles (10, 20, 30, 40, etc.).
    - Time markers: based on calculated ground speed, mark intervals (e.g., every 2 minutes).
    - Fraction markings: divide the leg into fractions (half, quarter, three-quarters, etc.).
- **Explanation**
  Fan lines are rarely used in practice at flyby, but may be used in other schools. Distance markers are useful for tracking progress. Time markers are preferred as they relate to ETA calculations and current position. Fraction markings are generally not used.
- **Considerations**
- Use time markers for best accuracy and utility.
- Fan lines and fraction markings are not standard at flyby.

Ground Speed and ETA Revision

> Ground speed is used for navigation calculations, not true airspeed (TAS). ETA calculations and time markers depend on ground speed for each leg.

- **Keypoints**
  - Use ground speed, not TAS, for navigation and time calculations.
  - Calculate time for each leg: distance divided by ground speed.
  - Mark intervals on the map based on time flown at ground speed.
- **Explanation**
  For example, if ground speed is 65 knots and the distance is 90 nautical miles, time = 90 / 65 = 1 hour and 23 minutes. Divide the leg into intervals based on how many nautical miles are flown every 2 minutes.
- **Considerations**
- Always use ground speed for navigation calculations.

Mnemonic for Track Error and Closing Angle: TEKA

> A mnemonic to remember which value to use for track error angle (distance gone) and closing angle (distance to go): TEKA.

- **Keypoints**
  - Track Error uses distance gone.
  - Closing Angle uses distance to go.
  - Mnemonic: TEKA (Track Error, distance gone; Closing Angle, distance to go).
- **Explanation**
  Remembering TEKA helps avoid confusion between which distance to use in each formula.
- **Considerations**
- Use the mnemonic TEKA to avoid mistakes in calculations.

Flight Time and Ground Speed Calculation

> Calculating the time required to travel a given distance at a specified ground speed, and adjusting calculations when the aircraft is behind schedule. Includes recalculating ETA and ground speed based on actual performance.

- **Keypoints**
  - Time = Distance / Ground Speed
  - If behind schedule, recalculate ETA using actual ground speed
  - Adjust calculations when actual time differs from planned time
- **Explanation**
  The class worked through a scenario where an aircraft departs at 09:00 Zulu from point A to point B, a distance of 250 nautical miles, at an average ground speed of 115 knots. After 75 nautical miles, the aircraft is 1.5 minutes behind schedule. The

instructor led the students through recalculating the ETA at point B, first by finding the time spent on the first leg (75 nm at 115 knots = 39 minutes), then adjusting for the delay (actual time 40.5 minutes). The real ground speed was recalculated as 75 / 40.5 * 60 = 111 knots. The remaining distance (175 nm) was then divided by the new ground speed to find the remaining time, and the total flight time was summed to find the revised ETA.

- **Examples**

  > An aircraft departs at 09:00 Zulu from point A to point B (250 nm). After 75 nm, it is 1.5 minutes late. The planned ground speed was 115 knots. The actual time for 75 nm is 40.5 minutes, so the real ground speed is 111 knots. The remaining 175 nm will take 1 hour 34 minutes and 35 seconds at this speed. The total flight time is 40.5 minutes + 1 hour 34 minutes 35 seconds = 2 hours 15 minutes 5 seconds. The revised ETA at point B is 11:15:05 Zulu.

  - Calculate planned time for 75 nm: 75 / 115 * 60 = 39 minutes.
  - Actual time is 40.5 minutes, so the aircraft is 1.5 minutes late.
  - Real ground speed: 75 / 40.5 * 60 = 111 knots.
  - Time for remaining 175 nm: 175 / 111 * 60 = 94.59 minutes (1 hour 34 minutes 35 seconds).
  - Total time: 40.5 + 94.59 = 135.09 minutes (2 hours 15 minutes 5 seconds).
  - ETA: 09:00 + 2:15:05 = 11:15:05 Zulu.
- **Considerations**
- Always use actual times and speeds for recalculations.
- Be precise with seconds when calculating ETA.
- Check for errors in initial calculations and adjust as needed.
- **Special Circumstances**
- If encountering a situation where the aircraft is ahead of schedule, recalculate ETA using the faster ground speed.
- If actual ground speed fluctuates during flight, recalculate ETA at each significant change.

1 in 60 Rule for Track Error and Heading Correction

> The 1 in 60 rule is used in navigation to estimate track error and required heading correction. For every 1 degree off track, after 60 nautical miles, the aircraft will be 1 nautical mile off course.

- **Keypoints**
  - Track error (degrees) = (distance off track / distance flown) * 60
  - Heading correction = track error + closing angle
  - Used to correct navigation when off track

- **Explanation**
  The instructor explained how to use the 1 in 60 rule to determine track error and heading correction. For example, after 30 nm, if the aircraft is 1 nm off track, the error is (1/30)*60 = 2 degrees. If 3 nm off after 30 nm, the error is 6 degrees. To fly directly to the destination, add the closing angle based on remaining distance.
- **Examples**

  > After 30 nm, the aircraft is 3 nm right of track, with 10 nm left to destination. Track error is (3/30)*60 = 6 degrees. Closing angle is (3/10)*60 = 18 degrees. Total heading correction required is 6 + 18 = 24 degrees.

  - Calculate track error: (3/30)*60 = 6 degrees.
  - Calculate closing angle: (3/10)*60 = 18 degrees.
  - Total correction: 6 + 18 = 24 degrees.
- **Considerations**
- Apply the 1 in 60 rule for both track error and closing angle.
- Use accurate measurements for distance off track and distance to go.
- **Special Circumstances**
- If encountering a situation with very short remaining distance, heading correction may be very large; consider alternative navigation strategies.

Fuel Calculation for Flight

> Calculating total fuel required for a flight based on fuel flow, airspeed, and wind component.

- **Keypoints**
  - Total fuel = (distance / ground speed) * fuel flow
  - Adjust for headwind or tailwind to find ground speed
  - Block fuel includes all fuel needed for the flight
- **Explanation**
  The instructor described a scenario where the flight from Burgos to Vitoria requires calculating total fuel needed. Given a fuel flow of 18 liters per hour, true airspeed of 105 knots, and average headwind of 9 knots, students are to find the total fuel required. First, determine the ground speed by subtracting the headwind from true airspeed, then calculate the time required for the distance, and finally multiply by the fuel flow.
- **Examples**

  > Flight from Burgos to Vitoria. Fuel flow: 18 liters/hour. True airspeed: 105 knots. Headwind: 9 knots. Distance: (students to measure on map). Ground speed = 105 - 9 = 96 knots. Time = distance / 96. Total fuel = time * 18 liters/hour.

  - Determine ground speed: 105 - 9 = 96 knots.

    - Measure distance on map (e.g., 50 nm).
    - Time = 50 / 96 = 0.52 hours (31.25 minutes).
    - Total fuel = 0.52 * 18 = 9.36 liters.
- **Considerations**
- Always use actual ground speed, accounting for wind.
- Include contingency fuel as required by regulations.
- **Special Circumstances**
- If encountering unexpected headwinds, recalculate fuel requirements during flight.

Practical Map Reading and Plotting in Navigation

> The importance of accurate map reading, plotting, and use of navigation tools (such as plodders and maps) in flight planning and navigation exercises.

- **Keypoints**
    - Use maps and plodders to measure distances accurately
    - Practice plotting courses and measuring headings
    - Understand the importance of accurate navigation for flight safety
- **Explanation**
  The instructor emphasized the need for students to bring maps and plodders for navigation exercises, and discussed the types of questions that may appear in exams, such as measuring distances between points (e.g., Burgos to Sardinia).
- **Examples**
  > Students are asked to measure the distance from Burgos to Vitoria using a map and plodder, then use this distance in fuel and time calculations.

    - Obtain map and plodder.
    - Measure straight-line distance between two points.
    - Use measured distance in subsequent calculations.
- **Considerations**
- Bring required navigation tools to class and exams.
- Practice using maps and plodders before the exam.
- **Special Circumstances**
- If encountering a situation where maps are unavailable, coordinate with the instructor to obtain them before the exercise.

Calculation of Block Fuel for a Flight

> Block fuel is the total amount of fuel required for a flight, including trip fuel, contingency fuel, alternate fuel, and reserve fuel. The calculation involves

> determining each component based on distance, ground speed, fuel flow, and regulatory requirements.

- **Keypoints**
  - Trip fuel: Fuel required to fly from departure to destination (Burgos to Vitoria).
  - Contingency fuel: 5% of trip fuel.
  - Alternate fuel: Fuel required to fly from destination to alternate airport (Vitoria to Bilbao).
  - Reserve fuel: Minimum required by SOP or regulations (45 minutes for fly-by SOP, 30 or 45 minutes per EASA).
  - Block fuel: Sum of trip, contingency, alternate, and reserve fuel.
- **Explanation**
  The process starts by calculating the ground speed (e.g., 95), then determining the time to fly a given distance (e.g., 50 nautical miles divided by ground speed). Time is converted to decimal hours or minutes as needed. Fuel consumption is calculated using the fuel flow rate (e.g., 18 liters per hour) and the time for each segment. Trip fuel is calculated for the main route, contingency fuel is 5% of trip fuel, alternate fuel is calculated for the route to the alternate airport, and reserve fuel is based on regulatory requirements. All these are summed to get the block fuel (e.g., 9.47 + 5.1 + 0.47 + 13.5 = 28.54 liters).
- **Examples**
  > Given: Distance from Burgos to Vitoria is 50 nautical miles. Ground speed is 95. Time to fly is calculated as 31.57 minutes (in decimal). Fuel flow is 18 liters per hour. Trip fuel: 31.57 minutes × 18 / 60 = 9.47 liters. Contingency fuel: 5% of trip fuel = 0.47 liters. Alternate airport is Bilbao, distance from Vitoria is 27 nautical miles. Time to alternate: 27 / 95 = 0.28 hours (17 minutes). Alternate fuel: 17 minutes × 18 / 60 = 5.1 liters. Reserve fuel: 45 minutes × 18 / 60 = 13.5 liters. Block fuel: 9.47 + 0.47 + 5.1 + 13.5 = 28.54 liters.

  - Calculate ground speed (given as 95).
  - Calculate time for main route: 50 nautical miles / 95 = 31.57 minutes.
  - Convert time to decimal if needed.
  - Calculate trip fuel: 31.57 × 18 / 60 = 9.47 liters.
  - Calculate contingency fuel: 5% of 9.47 = 0.47 liters.
  - Determine alternate airport (Bilbao), distance is 27 nautical miles.
  - Calculate time to alternate: 27 / 95 = 0.28 hours (17 minutes).
  - Calculate alternate fuel: 17 × 18 / 60 = 5.1 liters.
  - Calculate reserve fuel: 45 × 18 / 60 = 13.5 liters.
  - Sum all components: 9.47 + 0.47 + 5.1 + 13.5 = 28.54 liters.
- **Considerations**
- Always use exact numbers as given, do not round or simplify.

- Ensure correct conversion between minutes, seconds, and decimal hours.
- Follow SOP and regulatory requirements for reserve fuel.
- In real-life planning, account for route complexity and possible deviations.
- Check minimum fuel requirements on official websites.
- **Special Circumstances**
- If encountering a situation where the SOP and regulatory requirements differ for reserve fuel (e.g., SOP says 45 minutes, regulation says 30 minutes), use the higher value as per SOP unless otherwise instructed.
- If the route is not straight or involves multiple legs, adjust calculations to account for each segment and possible changes in ground speed or fuel flow.

Conversion of Time and Units in Aviation Calculations

> Accurate conversion between minutes, seconds, and decimal hours is essential in aviation calculations, especially for determining flight time and fuel consumption.

- **Keypoints**
  - Time may be given in minutes and seconds or as a decimal.
  - Conversion is necessary for accurate fuel calculations.
  - Fuel flow rates are typically given per hour, requiring time in hours or conversion from minutes.
- **Explanation**
  During the calculation, time for the flight segment was given as 31 minutes and 34 seconds, which needed to be converted to decimal (e.g., 31.57 minutes). This ensures that when multiplying by the fuel flow rate (liters per hour), the result is accurate. Similarly, time to alternate was calculated as 17 minutes, which is 0.28 hours.
- **Considerations**
- Double-check conversions to avoid calculation errors.
- Use decimal hours when multiplying by hourly rates.

Regulatory Requirements for Reserve Fuel

> Reserve fuel requirements are set by regulations and SOPs. For VFR single engine piston aircraft, EASA requires 30 minutes by day and 45 minutes by night. The fly-by SOP requires 45 minutes at all times.

- **Keypoints**
  - EASA regulation: 30 minutes by day, 45 minutes by night.
  - Fly-by SOP: 45 minutes regardless of time of day.
  - Reserve fuel is calculated as time (in minutes) × fuel flow rate / 60.

- **Explanation**
  In the example, reserve fuel was calculated as 45 × 18 / 60 = 13.5 liters, following the fly-by SOP. The instructor clarified that if the exam specifies fly-by SOP, use 45 minutes; otherwise, use 30 minutes if only reserves are mentioned.
- **Considerations**
- Always clarify which regulation or SOP applies before calculating reserve fuel.
- Use the higher value if in doubt.
- **Special Circumstances**
- If encountering a scenario where the exam or real-life situation does not specify which reserve fuel standard to use, default to the more conservative (higher) value.

Minimum Fuel Requirements

> Official IASA document states that final reserve fuel/energy should not be less than required energy to fly for airplanes. For VFR by day: 30 minutes of holding speed at 1,500 feet above the destination. For VFR by night and IFR: 45 minutes of holding speed at the same altitude. Helicopters are not included.

- **Keypoints**
  - Day VFR: 30 minutes at 1,500 feet above destination
  - Night VFR/IFR: 45 minutes at 1,500 feet above destination
  - Flyby SOPs: 45 minutes for both day and night for safety
- **Explanation**
  The minimum fuel requirements are set to ensure that aircraft have enough fuel to hold above the destination in case of delays or emergencies. The requirements differ for day and night operations, with night and IFR requiring more reserve due to increased risk.
- **Examples**
  > For a flight under VFR by day, the reserve fuel must be enough for 30 minutes of holding at 1,500 feet. For VFR by night or IFR, it must be enough for 45 minutes.

  - Determine the holding speed and fuel consumption rate at 1,500 feet.
  - Multiply the fuel consumption rate by 30 or 45 minutes as required.
  - Ensure this amount is included in total fuel planning.
- **Considerations**
- Always plan for the higher reserve (45 minutes) for safety.
- Account for aircraft mass and passenger weight when calculating fuel.
- **Special Circumstances**
- If flying overweight, ensure mass and balance calculations are still within CG limits.

Mass and Balance Calculations

> Calculating the aircraft's mass and balance is crucial for safe flight. This includes determining empty aircraft mass, pilot and passenger weights, fuel, and baggage. The useful load is the total mass available for payload and fuel after accounting for the empty mass.

- **Keypoints**
  - Empty aircraft mass example: 400 kilograms
  - Pilot weight: 85 kilograms
  - Passenger (instructor) weight: 80 kilograms
  - Useful load: 199 kilograms
  - Maximum takeoff weight: 600 kilograms
- **Explanation**
  Add up the empty mass, pilot, passenger, fuel, and baggage. Compare the total to the maximum takeoff weight. Calculate CG to ensure it's within operating limits. If overweight, check if CG is still within limits.
- **Examples**
  > Empty aircraft mass: 400 kg, pilot: 85 kg, instructor: 80 kg, fuel: full tanks (value not specified), useful load: 199 kg, maximum takeoff weight: 600 kg.

  - Sum all weights: 400 + 85 + 80 + fuel.
  - If total exceeds 600 kg, aircraft is overweight.
  - Calculate CG: e.g., 472.3, check if within operating range.
  - Convert CG to percentage of MAC: 472.3 x 100 / 1500 = 31.4.
- **Considerations**
- Do not use random weights for pilots/instructors; use actual values when possible.
- Overweight operations may still be within CG limits but are not legal.
- **Special Circumstances**
- If overweight, ensure CG is within limits and be aware of legal implications.

Fuel Planning: Trip, Alternate, Contingency, Reserve

> Total fuel required for a flight includes trip fuel (from A to B), alternate fuel (to nearest alternate airport), contingency fuel (5% of trip fuel), and reserve fuel (minimum holding requirement).

- **Keypoints**
  - Trip fuel: calculated based on distance and fuel flow
  - Alternate fuel: fuel required to reach alternate airport (e.g., 5.1 liters for 17 minutes)
  - Contingency fuel: 5% of trip fuel (e.g., 0.47 liters if trip fuel is 9.47 liters)

    - Reserve fuel: 45 minutes at holding speed (e.g., 13.5 liters if 18 liters/hour consumption)
- **Explanation**
  Calculate each component separately. Add trip, alternate, contingency, and reserve fuel to get total fuel required (e.g., 38.54 liters).
- **Examples**
  > Fuel flow: 18 liters/hour. Trip fuel: 9.47 liters. Alternate fuel: 5.1 liters for 17 minutes. Contingency fuel: 0.47 liters (5% of trip fuel). Reserve fuel: 13.5 liters (45 minutes at 18 liters/hour). Total fuel: 38.54 liters.

    - Calculate trip fuel based on distance and fuel flow.
    - Determine alternate fuel for 17 minutes at 18 liters/hour.
    - Calculate contingency fuel: 5% of 9.47 = 0.47 liters.
    - Calculate reserve fuel: 45 x 18 / 60 = 13.5 liters.
    - Sum all components for total fuel: 38.54 liters.
- **Considerations**
- Always include contingency fuel for deviations due to weather or ATC.
- Reserve fuel is mandatory and must not be omitted.
- **Special Circumstances**
- If route deviations occur, contingency fuel allows for extra consumption.

Cadbury Method for Compass, Magnetic, and True Headings

> The Cadbury method is a mnemonic for converting between compass, magnetic, and true headings using variation and deviation. The rule is: when going from left to right (compass to true), subtract west and add east; from right to left (true to compass), add west and subtract east.

- **Keypoints**
    - Compass to magnetic: apply deviation
    - Magnetic to true: apply variation
    - West: subtract left to right, add right to left
    - East: add left to right, subtract right to left
- **Explanation**
  Given a heading and known variation/deviation, apply the rules to convert between compass, magnetic, and true headings. Practice with sample values.
- **Examples**
  > True heading: 178. Variation: 7 east. Deviation: 2 west. Find compass heading.

    - True to magnetic: 178 - 7 (east, right to left) = 171.
    - Magnetic to compass: 171 + 2 (west, right to left) = 173.

    - Compass heading is 173.
- **Considerations**
- Always check the direction (left to right or right to left) before applying the rule.
- Variation and deviation must be provided for accurate calculation.
- **Special Circumstances**
- If deviation or variation is missing, calculation cannot proceed.

Wind Down Method for Heading and Ground Speed

> The wind down method is used to determine the required heading and ground speed given true airspeed, wind direction and speed, and true track.

- **Keypoints**
    - Determine drift angle (e.g., 11 degrees left)
    - Correct heading by adding/subtracting drift angle
    - Calculate ground speed using wind correction chart or manual calculation
- **Explanation**
  Given true airspeed (e.g., 100 knots), wind (230 at 20), and true track (140), calculate drift (e.g., 11 degrees left), correct heading (140 + 11 = 151), and read ground speed from chart (e.g., 98 knots).
- **Examples**
  > True airspeed: 100 knots. Wind: 230 at 20. True track: 140. Drift: 11 degrees left. Heading: 151. Ground speed: 98 knots.

    - Determine drift direction and angle.
    - Apply correction to true track to get heading.
    - Read ground speed from wind correction chart.
- **Considerations**
- Always determine drift direction (left or right) before correcting heading.
- Use accurate wind data for calculation.
- **Special Circumstances**
- If wind data is unavailable, estimation may be required but is less accurate.

Assignments & Suggestions

- Complete 100% of the lessons and 100% of the tests.
- Finish the progress test and the second progress test as indicated.
- Start with practical navigation and air pilotage (dead reckoning) lessons.
- Use map, calculator, plotter, watch, compass, and airspeed indicator for navigation exercises.

- Complete the exam section on field planning, including all questions in the question box.
- Bring plotter and map to the exam for distance and fuel calculations.
- Bring Burgos and Burbas maps to class by 2025-06-05.
- Bring plodder and other navigation tools for map exercises.
- Practice measuring distances on maps and calculating fuel requirements.
- Prepare for navigation calculation questions for the upcoming exam.
- Read the slides and notes on the board before Friday.
- Do the question bank as much as possible.
- Watch the video on how to fill the slide board.