03-06-2025 - GNav Lecture 3

> Date & Time: 2025-06-03 17:05:55
> Location: [Insert Location]
> [Insert Title]
> `Minimum Altitude` `Climb Gradient` `Aircraft CG`

Theme

This lecture covers precise flight performance calculations including determining minimum safe altitude over obstacles, calibrating altimeters and correcting for temperature errors, computing climb gradients for obstacle clearance, and calculating aircraft center of gravity using moments and lever arms. Detailed examples illustrate safety margins and conversion factors crucial for reliable flight planning.

Takeaways

1. Schedule and planning: Finish GINA tomorrow (2025-06-04) and continue with lesson nine the following day (2025-06-05), with one topic starting on the same day.
2. Charted obstructions: Obstacles are marked on VFR charts once they exceed 100 meters AGL (328 meters), with numerical examples such as 1960 (AMSL) and 965 (AGL).
3. Minimum altitude calculation for charted obstacles: Identify the route waypoints, take a 5 nautical mile sector on each side, round up the highest obstacle to the next 100 feet, and add a safety margin of 1,000 feet.
4. Handling uncharted terrain peaks: For terrain features (e.g., mountains) not detailed on the chart, determine the elevation from the VFR chart, then add an additional 300 feet (to account for possible uncharted obstacles like radio masts) before adding the 1,000 feet safety margin.
5. Example calculations: An obstacle of 882 feet is rounded to 900 and then 1,000 feet are added, resulting in a minimum altitude of 1,900 feet; a terrain peak with a spot of 830 feet becomes 900 + 300 + 1,000 = 2,200 feet minimum altitude; a mountain of 4200 feet with additional margins results in a safe altitude of 5500 feet.
6. Altitude quadrangles (MEF): The Maximum Elevation Field represents the maximum terrain elevation within a half degree (30 minutes) of latitude and longitude, with at least 1,000 feet added to obtain the safety altitude.
7. Altimeter and QNH vs QFE: The process involves checking the airport elevation from AIB, setting QNH to match the airport's altitude on the altimeter (e.g., 750 feet,

330 feet), and using QFE for runway threshold references.
8. True altitude correction using CFP5: By aligning the pressure altitude (e.g., 5000 feet) with the outside temperature (e.g., -20°C) on a CFP5 chart, pilots determine the true altitude (e.g., 4550 feet) to account for temperature-related errors.
9. Barometric and temperature errors: Emphasis on checking and updating altimeter settings to avoid common errors due to incorrect pressure settings and temperature variations.
10. Calculation of minimum altitude to safely clear an obstacle by rounding the hill's spot height to the next 100, adding a safety margin of 300 feet (or 329 in some cases) plus an additional 1000 feet.

Highlights

- `"The main principle is here, not to confuse when to add and when not to add."-- Speaker 1 《Lecture on Minimum Altitude Calculation, 2025-06-03》`
- `"Whenever I'm on final approach, I have to maintain 600 feet per minute descent rate to ensure I touch down in the correct zone."-- [Speaker 1]`
- `"Everything is very easy."-- Speaker 1`
- `"Precision in calculation is not just about numbers; it's the cornerstone of ensuring safe and balanced flight."-- Speaker 3 《Lecture, 2025-06-03》`

Chapters & Topics

Minimum Safe Altitude Calculation

> This knowledge point covers how to determine the minimum safe altitude along a route by evaluating obstacles and terrain features. For obstacles marked on charts, the height is rounded up to the next 100 feet, and a safety margin of 1,000 feet is added. For uncharted terrain features like mountain peaks, an additional 300 feet is included to account for possible unrecorded obstacles.

- **Keypoints**
  - Assess obstacles within a 5 nmi sector around the route.
  - Round obstacle height up to the next 100 feet.
  - Add 1,000 feet safety margin for charted obstacles.
  - For terrain peaks (e.g., mountains), add an extra 300 feet before adding the safety margin.
  - Example: An obstacle of 882 feet becomes 900 feet, leading to a safe altitude of 1,900 feet.

    - Example: Terrain with a spot of 830 feet becomes 900 + 300 + 1,000 = 2,200 feet.
- **Explanation**
  The calculation process starts by identifying the highest obstacle along the route within 5 nautical miles. If the obstacle is visible on the chart, its height is rounded up to the next hundred and 1,000 feet are added. However, if the terrain is uncharted (such as a mountain peak), the elevation from the chart is used instead, with an extra 300 feet added to cover potential uncharted structures (e.g., radio masts). In one example, a mountain with an elevation of 4200 feet requires the addition of 300 feet plus a 1,000 feet safety margin, resulting in a minimum altitude of 5500 feet. This method ensures that the aircraft remains clear of any obstacles even when visual confirmation might be compromised.
- **Examples**
  > For an obstacle on the chart with a recorded height of 882 feet, the number is rounded up to 900 feet and then 1,000 feet are added. The final minimum altitude maintained is 1,900 feet.

    - Identify the obstacle height (882 feet).
    - Round up to the nearest 100 feet (900 feet).
    - Add the standard safety margin of 1,000 feet.
    - Resulting minimum altitude: 900 + 1000 = 1900 feet.

  > For a terrain spot with a height of 830 feet, since it might not show all potential obstacles (like a hidden radio mast), the height is rounded up to 900 feet, then 300 feet and a 1,000 feet safety margin are added, resulting in a required minimum altitude of 2,200 feet.

    - Identify the terrain spot height (830 feet) and round up to 900 feet.
    - Add 300 feet additional margin for potential uncharted obstacles.
    - Add a further 1,000 feet as the safety margin.
    - Resulting minimum altitude: 900 + 300 + 1000 = 2200 feet.
- **Considerations**
- Differentiate properly between charted obstacles and uncharted terrain peaks.
- Ensure that rounding and margin additions are applied in the correct order.
- **Special Circumstances**
- If flying over mountainous regions where additional structures might exist, confirm the mountain elevation and add the extra 300 feet before the standard 1,000 feet margin.

Altimeter Calibration and True Altitude Correction

> This knowledge point explains the importance of calibrating the altimeter by setting QNH correctly to match the airport elevation, as well as the differences between

> QNH and QFE. It also covers the process of correcting the indicated altitude for temperature errors using devices like the CFP5, ensuring that the true altitude is accurately determined.

- **Keypoints**
  - QNH is used to set the altimeter so that it displays the airport's elevation above sea level.
  - QFE is adjusted to reflect the altitude relative to the runway threshold (zero reading on the altimeter).
  - Using AIB to verify airport elevation ensures all pilots in the vicinity maintain the same altitude.
  - CFP5 helps to calculate true altitude by correcting the pressure altitude reading with the outside temperature.
  - An example calculation involves a pressure altitude of 5000 feet and an outside temperature of -20°C, resulting in a true altitude reading of approximately 4550 feet.
- **Explanation**
  Pilots begin by checking the airport elevation in the AIB section and then setting the QNH on the aircraft's altimeter so that it matches the known elevation (for example, 750 feet). For operations referencing the runway threshold, QFE is set by adjusting the altimeter until it reads zero at the threshold. The CFP5 device is used for temperature corrections where the known pressure altitude (e.g., 5000 feet) and the actual outside temperature (e.g., -20°C) are aligned, resulting in a corrected true altitude (e.g., 4550 feet). This process is critical to ensure safe separation and to avoid errors that may arise from barometric changes or temperature variance.
- **Examples**
  > In a scenario where the pressure altitude is 5000 feet and the outside temperature is -20°C, pilots use the CFP5 device by aligning these values, which yields a true altitude of 4550 feet. This correction compensates for the differences between indicated altitude and the actual altitude due to temperature variation.

  - Identify the pressure altitude (5000 feet) and the outside temperature (-20°C).
  - Use the CFP5 device to align the altitude and temperature values.
  - Read the corrected true altitude from the outer scale, which in this example is 4550 feet.
- **Considerations**
- Always verify altimeter settings with the latest QNH from the meteorological data.
- Be aware of the differences between QNH (sea level reference) and QFE (runway threshold reference).
- **Special Circumstances**

- If operating in regions with significant temperature or pressure variations, perform frequent recalibrations using devices like the CFP5 to ensure the indicated altitude matches the true altitude.

Climb Gradient and Top of Climb Calculations in Obstacle Clearance

> This knowledge point explains how to compute the minimum altitude required to safely clear an obstacle along a flight path. It involves rounding the hill's spotlight height (from 1,325 feet to the next 100), adding a safety margin (300 feet plus an additional 1,000 feet), and then determining the altitude difference relative to the airfield elevation (233 feet). The altitude difference (2,700 - 233 = 2,467 feet) is divided by the distance converted from nautical miles to feet (6 NM = 36,480 feet) to compute a climb gradient of roughly 6.7%. This is additionally converted to a feet per minute rate (approximately 145 feet per minute) given a ground speed of 65 knots, ensuring a safe climb profile.

- **Keypoints**
  - Airfield elevation is 233 feet and the obstacle's spot height is 1,325 feet.
  - Rounded spot height and safety margins result in a calculated altitude of 2,700 feet for safe clearance.
  - Altitude difference is calculated as 2,700 feet minus 233 feet equals 2,467 feet.
  - Climb gradient is determined by converting 6 NM to 36,480 feet and applying the percentage formula, resulting in approximately 6.7%.
  - Ground speed is calculated as 65 knots after considering a 5-knot headwind from a 70-knot climb airspeed.
- **Explanation**
  The process begins by rounding the obstacle's height and then adding required safety margins. The altitude difference between the resulting safe altitude (2,700 feet) and the airfield elevation (233 feet) gives a climb requirement of 2,467 feet over 6 NM. Conversion of these 6 NM to 36,480 feet allows calculation of the climb gradient as (2,467/36,480)*100 resulting in approximately 6.7%. Further, dividing 2,467 feet by the time taken (derived from a ground speed of 65 knots covering 6 NM in about 5.5 minutes) yields approximately 145 feet per minute, confirming that the aircraft's performance is adequate for obstacle clearance.
- **Examples**
  > A flight is planned from an airfield at 233 feet where a hill with a spot height of 1,325 feet is located 6 nautical miles directly on track. The safety procedure involves rounding 1,325 feet upward to 1,409 feet, adding 300 feet plus an extra 1000 feet to achieve a safe clearance altitude of 2,700 feet. Subtracting the airfield elevation (233 feet) from this altitude gives an altitude difference of 2,467 feet. After converting 6 nautical miles to 36,480 feet, the computed climb gradient is approximately 6.7%, which equates to about 145 feet per minute when considering a ground speed of 65 knots.

    - Round the obstacle height (1,325 feet) to the next 100 to get approximately 1,409 feet.
    - Add safety margins (300 feet and 1,000 feet) to reach a safe altitude of 2,700 feet.
    - Calculate the altitude difference: 2,700 feet - 233 feet = 2,467 feet.
    - Convert 6 nautical miles to feet: 6 x 6,800 feet = 40,800 feet; however, the transcript uses 36,480 feet, confirming a specific conversion factor in use.
    - Determine the climb gradient: (2,467/36,480) x 100 ≈ 6.7%, which translates to approximately 145 feet per minute climb rate.
- **Considerations**
- Ensure all numerical values remain exactly as stated.
- Conversion of nautical miles to feet can vary based on the factor used; the transcript uses 6,800 feet per NM in one case and 36,480 for 6 NM.
- Be meticulous in applying safety margins and rounding rules as described.
- **Special Circumstances**
- If obstacles are below 500 feet or obstructions below 100 meters, refer to the chart notes to determine if additional clearance is necessary.

Descent Rate and Glide Slope Calculations for Safe Approach

> This knowledge point covers calculating the descent rate necessary for a safe approach and landing using a 3° glide slope. It explains the rule-of-thumb that at a ground speed of 120 knots, multiplying by 5 yields a descent rate of 600 feet per minute, ensuring proper alignment with the touchdown zone. Additional examples demonstrate how to determine the required descent over a given distance by subtracting altitudes, converting time based on ground speed, and dividing the altitude change by the time to obtain the rate of descent.

- **Keypoints**
    - For a 3° glide slope at 120 knots, the required descent rate is approximately 600 feet per minute.
    - A rule-of-thumb states that being 3 nautical miles from the runway requires an altitude of roughly 1,000 feet.
    - Example: Descending from 7,000 feet to 1,000 feet (6,000 feet difference) over a calculated distance may require an 18 nautical mile path.
    - Rate of descent calculations involve dividing the total altitude change by the time derived from the distance and ground speed.
- **Explanation**
  The instructor demonstrated that for landing, maintaining the correct glide slope is critical. At a ground speed of 120 knots, multiplying the speed by 5 provides a descent rate of 600 ft/min. In another example, descending from 9,500 feet to 1,000

feet over 20 nautical miles was broken down by first calculating the altitude difference (8,500 feet) and determining the time (20 NM divided by ground speed in knots, converted into minutes), then dividing the altitude difference by this time to yield a minimal descent rate requirement. Such calculations ensure that the aircraft remains on the correct approach path and touches the runway at the designated touchdown zone.

- **Examples**

  > To descend from 9,500 feet to 1,000 feet over a distance of 20 nautical miles at a ground speed of 100 knots, the altitude change is determined (9,500 - 1,000 = 8,500 feet). The time taken to cover 20 nautical miles at 100 knots is calculated (e.g., 12 minutes). Dividing the altitude change (8,500 feet) by the time (12 minutes) results in an approximate descent rate of 708 feet per minute. This method ensures that the aircraft maintains the required glide slope for a safe landing approach.

  - Determine the altitude difference: 9,500 feet - 1,000 feet = 8,500 feet.
  - Calculate the time to cover 20 nautical miles at 100 knots (approximately 12 minutes).
  - Divide the altitude difference by the time: 8,500 feet / 12 minutes ≈ 708 feet per minute descent.
  - The calculation confirms that maintaining a descent rate close to the computed value is essential to stay on the 3° glide slope.
- **Considerations**
- Always verify the aircraft’s ground speed and adjust for any headwinds or tailwinds.
- On final approach, monitoring descent rate precisely is crucial as aircraft instruments typically adjust in increments (e.g., 50 ft/min).
- **Special Circumstances**
- If using VFR procedures where visual cues like PAPI lights are available, pilots might rely on them rather than strict numerical descent rates. However, for IFR and exam purposes, the calculated descent rates should be followed closely.

Minimum Climb Gradient Calculation for Obstruction Clearance

> This knowledge point covers the method to calculate the minimum climb gradient required to safely clear a mountain or any obstruction. The lecturer provided a detailed example where the mountain height is stated as 2000 feet, and after adding margins for potential obstructions on top and safety, the necessary altitude becomes 3300 feet. With an altitude difference of 2,550 feet (from a starting altitude of 650 feet) over a distance of 8 or 8.1 nautical miles and a ground speed of 55 knots, the calculated climb gradient is 292 feet per minute. The discussion also contrasts these calculated low values against typical climb rates in the initial phase

> of flight (ranging from 500 to 1,000 feet per minute) and explains the significance of these differences for safe flight operations.

- **Keypoints**
  - Original mountain height: 2000 feet.
  - Required altitude including margin: 3300 feet.
  - Altitude difference: 2,550 feet.
  - Distance used for calculation: 8 nautical miles (or 8.1 in one mention).
  - Calculated climb gradient: 292 feet per minute.
  - Typical early flight climb rates are usually higher (500 to 1,000 feet per minute).
- **Explanation**
  The process starts with determining the necessary altitude to clear a mountain by adding a margin to the mountain's height. Then, the altitude difference between the starting point and the target altitude is calculated. Dividing this altitude difference by the distance in nautical miles (and adjusting for ground speed conversion factors) gives the climb gradient in feet per minute. The example also emphasizes verifying if the computed gradient is within safe operational parameters compared to typical values in flight.
- **Examples**
  > Using the Burgos airport departure chart, the lecturer explained a scenario where the departure route via Ungas requires maintaining a 5% climb gradient up to 4000 feet. At a ground speed of approximately 100 knots, this corresponds to a minimum climb rate of about 500 to 506 feet per minute. This example links chart data directly to practical flight parameters without the need for pilots to recalculate during flight.

  - Identify the required climb gradient percentage (5% in this case).
  - Convert the percentage into feet per minute based on the aircraft's ground speed.
  - Confirm that the computed climb rate matches the prescribed value on the departure chart.
- **Considerations**
- Ensure that the safety margin is properly calculated to account for any potential obstructions like uncharted radio masts.
- Consider variations in ground speed during climb which might affect the required feet per minute climb rate.
- **Special Circumstances**
- If the computed climb gradient is significantly lower than usual (e.g., 292 feet per minute when typical values are 500-1,000 feet per minute), pilots should assess whether their aircraft performance can safely achieve the needed rate.

Aircraft Center of Gravity (CG) Calculation

> This knowledge point explains the method of calculating the Center of Gravity (CG) of an aircraft. It is based on the principle that the moment is equal to the mass multiplied by the lever arm. The instructor detailed that the manufacturer provides basic anti-mass and moment data which serve as the starting point. Additional loading, such as the weight of the pilot (e.g., 75 units) and other items, is considered along with their respective positions (lever arms, like 0.90 or 2.0 units) to determine the overall CG. The lecture also mentioned that a very small CG leads to significantly altered handling characteristics.

- **Keypoints**
  - Use the formula: Moment = Mass x Lever Arm.
  - Basic anti-mass moment is provided by the manufacturer.
  - Additional components such as pilot, passenger, fuel, and baggage are incorporated using their individual weights and lever arms.
  - Example provided where the pilot weight is 75 and lever arm values are provided (e.g., 0.90 for pilot and passenger, 2.0 for baggage).
- **Explanation**
  The calculation of the aircraft's CG involves summing up the moments of individual components and then dividing by the total mass. The lecturer emphasized that each element's position (lever arm) relative to a reference point is critical for determining overall aircraft stability. The process is straightforward if proper data is available from the aircraft's loading documentation.
- **Examples**
  > In this example, the basic loading of the aircraft is considered along with additional weights such as a pilot weighing 75 units. The lever arms for various components are taken from the provided data (e.g., 0.90 for both pilot and passenger, and 2.0 for baggage). These values are used to calculate the moment for each component, which when summed and divided by the total mass, gives the loaded aircraft CG.

  - Record the base moment provided by the manufacturer.
  - Add moments of all additional components using Moment = Mass x Lever Arm.
  - Divide the total moment by the total mass to find the CG position.
- **Considerations**
- Ensure all lever arm positions are accurately obtained from the official data (propaganda team provided data in the example).
- Be cautious if the CG is very small as it can result in reversed or opposite control responses.
- **Special Circumstances**

- If the CG is calculated to be unusually low, re-check the lever arm data and mass distribution as it could lead to non-standard aircraft handling behavior.

Calculation of Aircraft Center of Gravity (CG)

> This knowledge point details the procedure for calculating an aircraft's CG by summing the individual moments of various loads and dividing by the total aircraft mass. The lecture includes specific numerical examples such as a loaded mass of 950 kg and a total moment of 936.32, resulting in a CG positioned close to one meter from the front center.

- **Keypoints**
  - Total moment is obtained by adding individual moments (e.g., 75, 67.5, 72.5, 126, 75, 135).
  - Total loaded mass of the aircraft is 950 kg.
  - The CG is determined by dividing the summed moment by a lever arm factor (such as 6.75 or 10.5), illustrating the sensitivity of the CG position.
- **Explanation**
  The lecture walks through calculating the CG by first individually determining moments at different time steps, summing these moments to obtain 936.32, and then applying a division by a lever factor to find that the CG is near one meter from the front center. The process is crucial for ensuring proper aircraft balance and safe flight, and various scenarios were used to demonstrate differences when loading is altered.
- **Examples**
  > Using the given figures, six individual moments (75, 67.5, 72.5, 126, 75, 135) are summed to get a total moment of 936.32. When this total is divided by the aircraft's mass or a specific lever arm factor (6.75 or 10.5), it confirms that the CG is approximately one meter from the front center.

  - List each moment value as provided.
  - Sum the values to achieve a total of 936.32.
  - Apply division by the designated lever arm factor to ascertain the CG position.
- **Considerations**
- Maintain exact numerical values as provided without rounding.
- Ensure units remain consistent throughout the calculation (kg, cm).
- Verify the correct lever arm factor is applied in each context.
- **Special Circumstances**
- If there is a discrepancy between factors (e.g., 6.75 versus 10.5), determine the correct scenario to apply each factor.
- When adjustments in cargo distribution occur, recalculate the CG immediately to ensure safety.

Fuel Consumption Impact on Aircraft Balance

> This knowledge point explains how fuel consumption directly affects aircraft balance. The conversion of fuel volume to mass (1.5 litres multiplied by a specific gravity of 0.72 kg/litre equals 90 kg) alters the aircraft's moment, especially when considered alongside the fuel lever arm position.

- **Keypoints**
  - A fuel consumption volume of 1.5 litres converts to 90 kg when multiplied by 0.72 kg per litre.
  - The fuel lever arm is positioned at 90 cm, impacting the overall moment.
  - Accurate fuel consumption figures are vital for recalculating the aircraft's CG after fuel burn.
- **Explanation**
  The calculation involves converting fuel volume into mass (1.5 litres x 0.72 kg/litre = 90 kg) and then incorporating this mass into the moment balancing equations. This adjustment is essential to correctly determine the CG for both takeoff and landing scenarios, ensuring that fuel burn does not inadvertently shift the CG outside safe limits.
- **Examples**
  > An example provided shows that 1.5 litres of fuel, when converted (1.5 x 0.72), equals 90 kg. This 90 kg is then used in the moment calculation together with a fuel lever arm of 90 cm to assess the impact on the aircraft's balance.

  - Multiply 1.5 litres by 0.72 kg/litre to get 90 kg.
  - Apply the 90 kg fuel mass at a lever arm of 90 cm to evaluate its effect on the overall CG.
- **Considerations**
- Ensure the conversion factor for fuel (0.72 kg/litre) is used consistently.
- Maintain clear unit consistency between mass (kg) and distance (cm).
- Recognize the importance of timely recalculations as fuel is consumed during flight.
- **Special Circumstances**
- If fuel consumption values vary during flight, update the moment calculations in real time.
- Ensure that any changes in fuel weight are accurately reflected in CG computations.

Effects of Forward vs Aft Cargo Placement on CG

> This point covers how the placement of cargo in either the forward or rear compartments impacts the CG of an aircraft. The lecture compares calculations showing the forward compartment (with a moment of 178.700 divided by 1670

> resulting in 107 cm) and the aft cargo placement (with a moment of 1867 divided by 1670), and discusses acceptable CG limits.

- **Keypoints**
    - Forward cargo moment: 178.700 divided by 1670 yields a CG position of 107 cm.
    - Aft cargo moment: 1867 divided by 1670 is used for comparative analysis.
    - Proper CG management requires maintaining the CG within specific limits (e.g., between 90 and 1.1 in the given context).
- **Explanation**
  The instructor illustrated two scenarios for cargo placement. For forward cargo, dividing 178.700 by 1670 results in a CG located at 107 cm, which falls within the safe limit. In contrast, the aft placement scenario, calculated using 1867 divided by 1670, is compared to these limits to decide the optimal loading configuration. This analysis is critical in ensuring that the aircraft remains balanced under different loading conditions.
- **Examples**
  > The lecture provided a computation for forward cargo placement by dividing 178.700 by 1670 to obtain a CG value of 107 cm. A similar approach is taken for aft cargo with a moment of 1867, ensuring that the placement meets the defined CG limits.

    - Calculate the forward cargo CG: 178.700 / 1670 = 107 cm.
    - Calculate the aft cargo CG: 1867 / 1670.
    - Compare both results against the allowable range to determine optimal placement.
- **Considerations**
- Utilize the exact numerical values provided without approximation.
- Ensure consistent units throughout the calculations.
- Clarify any ambiguous limit values (e.g., ‘90 to 1.1’) to maintain safety.
- **Special Circumstances**
- If cargo configurations change during loading, immediately recalculate the CG.
- Double-check measurements when discrepancies in moment factors arise.

Assignments & Suggestions

- Complete the GINA module as scheduled: work on two topics on 2025-06-04 and finish GINA with lesson nine on 2025-06-05. Ensure that all calculations for minimum safe altitude and altimeter settings are reviewed and understood before the next session.
- Study for tomorrow’s muscle balance session.

- Review the slides on formulas, definitions, and instrument chart interpretations as discussed in class.
- Practice calculations for minimum climb gradient and aircraft CG using the provided numerical examples and scenarios from the lecture.