2025-05-27 - Performance lecture end +revision

> Date & Time: 2025-05-28 12:26:55
> Location: [Insert Location]
> [Insert Title]
> `center of gravity` `weight and balance` `aircraft loading`

Theme

This lecture provides a comprehensive overview of aircraft center of gravity (CG) and weight and balance calculations. It covers methods for determining CG, the impact of baggage and fuel placement, acceptable CG limits, and the importance of proper documentation and captain responsibility. Practical examples, formulas, and graphical methods are discussed to ensure safe aircraft operation within specified mass and balance limits.

Takeaways

1. Calculation of aircraft center of gravity (CG) using moments and mass
2. Effect of baggage placement (forward vs aft compartment) on CG
3. Acceptable CG limits (90 to 111 cm)
4. Calculation of fuel consumption impact on mass and CG
5. Conversion of fuel volume (liters) to mass (kilograms) using specific gravity
6. Calculation of moments for takeoff, fuel, and landing
7. Importance of proper aircraft loading and documentation
8. CG movement during flight due to fuel consumption
9. Ensuring CG remains within limits throughout flight
10. Step-by-step calculation process for CG at landing

Highlights

- `"There always should be what if. It's not like, okay, today I want to put it in the back or so, just throw away. No. He has to do the proper preparation, then the captain has to check it, then sign it."`

- `"So, how to find aircraft CG in the percentage of mean aerodynamic chord? We have to take our CG in mm, multiply by 100 and divide by length of mean aerodynamic chord."`
- `"The final responsibility for checking the aircraft's loading always rests with the aircraft commander, regardless of what passenger, co-pilot, owner, operator, handling agent, load master, or any other interested party has to say."`
- `"The point in which all the weight acts."`
- `"So it plays a really big role, I would say a huge role, on where you're placing your item."`
- `"If your CG is out of the limits, the aircraft will almost certainly be aerodynamically unstable, and may well crash."`

Chapters & Topics

Aircraft Center of Gravity (CG) Calculation

> The center of gravity (CG) of an aircraft is determined by calculating the total moment and dividing it by the total mass. The placement of baggage and fuel consumption during flight affect the CG position, which must remain within specified limits for safe operation.

- **Keypoints**
  - CG is calculated as total moment divided by total mass.
  - Moments are calculated by multiplying mass by lever arm (distance from datum).
  - Baggage placement in forward or aft compartments changes the CG.
  - Acceptable CG limits are specified (e.g., 90 to 111 cm).
  - Fuel consumption reduces mass and moment, shifting CG.
  - All calculations must be documented and checked by the captain.
- **Explanation**
  To calculate the CG, first determine the total moment by multiplying each mass (such as baggage, fuel, aircraft) by its respective lever arm. Sum all moments and divide by the total mass to find the CG position. When fuel is consumed, subtract the mass and moment of the fuel from the takeoff values to get landing values. Ensure the CG remains within the specified limits throughout the flight.
- **Examples**
  > An aircraft has a mass and CG position at takeoff of 950 kg and 110 cm aft of the datum. During flight, 125 liters of fuel (specific gravity 0.72) is consumed. The fuel lever arm is 90 cm aft of the datum. The task is to find the mass and CG position for landing.

- Convert fuel volume to mass: 125 liters × 0.72 kg/liter = 90 kg.
    - Calculate moment at takeoff: 950 kg × 110 cm = 104,500.
    - Calculate moment of fuel: 90 kg × 90 cm = 8,100.
    - Subtract fuel moment from takeoff moment: 104,500 - 8,100 = 96,400.
    - Subtract fuel mass from takeoff mass: 950 kg - 90 kg = 860 kg.
    - Calculate landing CG: 96,400 ÷ 860 = 112.09 cm aft of datum.
    - Compare with limits: If the limit is 110 cm, 112.09 cm is outside the limit.

    > If baggage is placed in the forward compartment (lever arm 60), the moment is 6,000. Dividing the total moment by the mass gives a CG of 107 cm aft. If baggage is placed in the aft compartment (lever arm 108 or 140), the CG shifts to 111.79 cm aft, which may be outside the acceptable limit.

    - Calculate moment for forward compartment: mass × 60 = 6,000.
    - Calculate CG: 178,700 ÷ 16,700 = 107 cm aft.
    - Check if within limits (90 to 111 cm): 107 cm is within limits.
    - For aft compartment, use lever arm 108 or 140.
    - Calculate new CG: moment ÷ mass = 111.79 cm aft.
    - Check if within limits: 111.79 cm is outside the limit.
- **Considerations**
- Always verify CG is within specified limits before and after flight.
- Proper preparation and documentation are required for loading.
- Captain must check and sign off on loading calculations.
- Do not arbitrarily change baggage placement without recalculating CG.
- **Special Circumstances**
- If encountering a situation where the CG is outside the limit after fuel consumption, recalculate loading or adjust fuel/baggage placement to bring CG within limits.
- If the aircraft is loaded within limits at takeoff but CG is outside limits at landing, this indicates an error in loading or calculation and must be corrected before flight.

Conversion of Fuel Volume to Mass

> To accurately account for fuel in weight and balance calculations, fuel volume in liters must be converted to mass in kilograms using the specific gravity of the fuel.

- **Keypoints**
    - Specific gravity is the mass per unit volume (e.g., 0.72 kg/liter).
    - Multiply fuel volume by specific gravity to get mass.
    - Accurate conversion is essential for correct CG and mass calculations.
- **Explanation**
  When given fuel in liters and needing mass in kilograms, multiply the number of

liters by the specific gravity (kg/liter). For example, 125 liters × 0.72 = 90 kg.

- **Examples**
  > Given 125 liters of fuel with a specific gravity of 0.72, calculate the mass.

  - Multiply 125 liters by 0.72 kg/liter.
  - Result: 90 kg.
- **Considerations**
- Always use the correct specific gravity for the type of fuel used.
- **Special Circumstances**
- If specific gravity is not provided, obtain it from fuel specifications or aircraft manual before performing calculations.

Aircraft Weight and Balance Calculation

> The process of determining whether an aircraft's weight and center of gravity (CG) are within permissible limits before flight. This involves calculating the total weight, moments, and CG location using specific formulas and referencing aircraft documentation.

- **Keypoints**
  - Identify aircraft type, registration, and relevant data from operation manuals.
  - Record basic empty mass (e.g., 400.8 kg), moment (e.g., 175,321 kg·mm), and CG position (e.g., 29.2% of MAC).
  - Add weights for pilot, passengers, baggage, and fuel (e.g., pilot 75 kg, fuel 80 kg).
  - Calculate total takeoff weight (e.g., 555.8 kg).
  - Calculate moments for each item (e.g., pilot: 75 kg × 700 mm = 52,500 kg·mm; fuel: 80 kg × 180 mm = 14,400 kg·mm).
  - Sum all moments to get total moment (e.g., 222,220 kg·mm).
  - Find CG location by dividing total moment by total weight (e.g., 435.8 mm).
  - Convert CG location to percentage of MAC: (CG in mm × 100) / length of MAC (e.g., 435.8 × 100 / 1500 = 29%).
  - Check if CG and weight are within specified limits (e.g., CG range 28%–35% of MAC, weight limits).
- **Explanation**
  The instructor walks through a detailed example using specific numbers: starting with the basic empty mass and moment, adding pilot and fuel weights, calculating their moments, summing up for total weight and moment, and then determining the CG both in mm and as a percentage of MAC. The process is repeated for zero-fuel weight by subtracting fuel. The graphical method is also demonstrated using a load sheet and balance chart, plotting the weights and CGs to visually confirm they are within limits.

- **Examples**
  > Given: Basic empty mass = 400.8 kg, moment = 175,321 kg·mm, pilot = 75 kg, fuel = 80 kg. Calculate total weight: 400.8 + 75 + 80 = 555.8 kg. Calculate moments: pilot (75 × 700 = 52,500), fuel (80 × 180 = 14,400). Total moment: 175,321 + 52,500 + 14,400 = 222,221 kg·mm. CG location: 222,221 / 555.8 = 400 mm (rounded for example). Percentage of MAC: (400 × 100) / 1500 = 26.7%. Check if within limits (e.g., 28%–35% of MAC).

  - Identify all weights and arms (distances from datum).
  - Multiply each weight by its arm to get moment.
  - Sum all weights and all moments.
  - Divide total moment by total weight to get CG in mm.
  - Convert CG to percentage of MAC.
  - Compare with aircraft's allowable CG range.
- **Considerations**
- Always use exact numbers as provided in the aircraft documentation.
- Double-check units (kg, mm, %).
- Ensure all compartments (baggage, wing lockers) are accounted for, even if unused.
- Verify that all data entries (registration, date, weights) are accurate.
- Use the correct formula for CG percentage.
- **Special Circumstances**
- If encountering a question on the exam that has not been seen before, apply the step-by-step calculation method as demonstrated.
- If the CG is outside the allowable range on the load sheet chart, adjust the load (e.g., remove baggage or fuel) and recalculate.
- If using a graphical method and the plotted point is outside the envelope, unload or redistribute weight as necessary.

Mean Aerodynamic Chord (MAC) and CG Calculation

> The mean aerodynamic chord (MAC) is a reference line used to express the center of gravity (CG) location as a percentage. The CG must be within specified limits, usually given as a percentage of MAC, to ensure safe flight characteristics.

- **Keypoints**
  - MAC connects the leading edge and trailing edge of the wing.
  - CG is calculated from the leading edge as a percentage of MAC.
  - Aircraft documentation provides the allowable CG range in mm and as a percentage of MAC (e.g., 28%–35%).
  - Formula: CG (%) = (CG in mm × 100) / length of MAC (in mm).

- **Explanation**
  The instructor explains that the CG location is measured from the leading edge of the MAC. For example, if the CG is at 29.2% of MAC, it means it is 29.2% of the chord length from the leading edge. The calculation is performed by multiplying the CG in mm by 100 and dividing by the MAC length.
- **Examples**
  > Given: CG location = 435.8 mm, MAC length = 1500 mm. Calculation: (435.8 × 100) / 1500 = 29%.

  - Take the CG location in mm.
  - Multiply by 100.
  - Divide by the MAC length in mm.
  - Result is the CG as a percentage of MAC.
- **Considerations**
- Always use the MAC length specified for the aircraft.
- Check both mm and percentage values against the allowable range.
- **Special Circumstances**
- If the MAC length changes (e.g., different aircraft), recalculate using the new value.
- If the CG is outside the allowable percentage, adjust loading accordingly.

Load Sheet and Balance Chart Usage

> A graphical method to verify that the aircraft's CG and weight are within safe limits. The load sheet and balance chart allow for plotting weights and CGs to visually confirm compliance.

- **Keypoints**
  - Plot empty aircraft CG and weight on the chart.
  - Add pilot, passengers, baggage, and fuel sequentially, moving along the chart as per instructions.
  - Use vertical and horizontal lines to track changes in weight and CG.
  - Check that the final CG for takeoff and zero-fuel weights are within the envelope.
  - If plotted point is outside the envelope, adjust loading.
- **Explanation**
  The instructor demonstrates plotting the empty aircraft CG and weight, then adding pilot and fuel by counting gaps (each representing 5 kg) and drawing lines as per the chart's instructions. The process is repeated for zero-fuel weight by subtracting fuel. The chart visually confirms whether the CG is within limits.
- **Examples**

> Empty CG: 29.2%, empty weight: 400.8 kg. Add pilot: 75 kg (15 gaps of 5 kg each). Add fuel: 80 kg (16 gaps). Plot takeoff weight: 555.8 kg. Draw lines as per chart to find takeoff and zero-fuel CGs.

  - Locate empty CG and weight on the chart.
  - Add each component by counting gaps and drawing lines.
  - Plot final takeoff and zero-fuel CGs.
  - Check if points are within the envelope.
- **Considerations**
- Each gap on the chart represents a specific weight increment (e.g., 5 kg).
- Accurately count gaps for each added weight.
- Use the correct chart for the specific aircraft.
- **Special Circumstances**
- If the plotted CG is outside the envelope, remove or redistribute weight and repeat the process.
- If unsure about the chart's increments, verify with the aircraft manual.

Aircraft Categories: Normal, Utility, Aerobatic

> Aircraft are classified into three categories: normal, utility, and aerobatic. Each category has specific definitions and permitted maneuvers. The normal category is like a cruiser, allowing only normal flight maneuvers such as stalls, lazy 8s, chandelles, and steep turns where the angle of bank does not exceed 60 degrees. Aerobatic maneuvers are not permitted in the normal category. The utility category allows all maneuvers permitted in the normal category, plus spins and steep turns with an angle of bank in excess of 60 degrees. The aerobatic category allows all maneuvers of the normal and utility categories, together with aerobatic maneuvers as stated in the EUHFM, subject to declared entry airspeeds and no traffic limits.

- **Keypoints**
  - Normal category: only normal flight maneuvers, angle of bank does not exceed 60°
  - Utility category: includes normal maneuvers plus spins and steep turns with angle of bank over 60°
  - Aerobatic category: includes all maneuvers from normal and utility, plus aerobatic maneuvers
- **Explanation**
  The Cessna 172 can be in either the normal or utility category depending on its load. If only one pilot is flying with not too much fuel, the aircraft is in the utility category. The category determines what maneuvers are permitted during flight.
- **Examples**

> If the Cessna 172 is loaded with only one pilot and not too much fuel, it can be in the utility category, allowing spins and steep turns with a 90-degree angle. If the weight is higher, it remains in the normal category, restricting maneuvers.

  - Determine the aircraft's weight and CG.
  - Refer to the mass and balance sheet to see if the aircraft falls within the utility or normal category envelope.
  - If in utility, more maneuvers are permitted; if in normal, aerobatic maneuvers are not allowed.
- **Considerations**
- Always check the aircraft's weight and CG before performing maneuvers.
- Do not exceed the permitted angle of bank for the category.
- **Special Circumstances**
- If the aircraft's weight is reduced (e.g., by burning fuel), it may move from normal to utility category, allowing additional maneuvers.

Mass and Balance Calculations

> Mass and balance calculations are essential for safe flight. The center of gravity (CG) is determined by dividing the total moment by the total mass. The moment is calculated by multiplying the mass of each item by its lever (distance from the datum). Accurate calculation ensures the aircraft is within safe operational limits.

- **Keypoints**
  - Moment = mass × lever (CG)
  - CG location = total moment / total mass
  - Mass and balance sheets are used to plot and verify CG and weight
  - Aircraft must remain within the CG and weight envelope for the intended category
- **Explanation**
  For example, a touring aircraft with a basic empty mass of 654.7 kg and a moment of 638.57. The pilot's mass is 75 kg, and additional payloads are added. The total moment and mass are calculated, and the CG is found by dividing the moment by the mass. This value is then checked against the mass and balance sheet to determine the category.
- **Examples**
  > A touring aircraft has a basic empty mass of 654.7 kg and a moment of 638.57. The pilot's mass is 75 kg. After adding all payloads and calculating the total moment and mass, the CG location is found to be 1.1 meters behind the datum.

  - Sum all masses (aircraft, pilot, payload).

  - Sum all moments (mass × lever for each item).
  - Divide total moment by total mass to find CG.
  - Check CG and weight on the mass and balance sheet to determine category.
- **Considerations**
- Always use exact numbers as provided; do not round or estimate.
- Verify all units (kg, pounds, meters, inches) and convert if necessary.
- **Special Circumstances**
- If the aircraft is overloaded or CG is out of limits, adjust load or fuel to bring it within limits.

Quiz: Weight and Center of Gravity Combinations

> To determine if a given weight and CG combination allows flight in the normal category, calculate the moment (mass × lever), divide by 1,000 if required, and plot the result on the provided graph. Only combinations within the normal category envelope are permitted.

- **Keypoints**
  - Calculate moment: mass × lever (CG)
  - Divide moment by 1,000 if graph requires
  - Plot weight and moment on the graph to check if within normal category
- **Explanation**
  Given several weight and CG combinations, calculate the moment for each, divide by 1,000, and plot on the graph. Only those within the normal category envelope are valid for normal category flight.
- **Examples**
  > Given a weight of 2,000 pounds and a CG of 35 inches, calculate the moment: 2,000 × 35 = 70,000. Divide by 1,000 to get 70. Plot 2,000 (weight) and 70 (moment/1,000) on the graph to check if within the normal category.

  - Multiply 2,000 by 35 to get 70,000.
  - Divide 70,000 by 1,000 to get 70.
  - Plot on the graph and check if within the normal category envelope.
- **Considerations**
- Always use the exact figures provided in the question.
- Check the graph's axes and units before plotting.
- **Special Circumstances**
- If the calculated point is outside the envelope, the aircraft cannot be flown in the normal category.

Fuel Conversion and Effect on Mass and Balance

> When fuel is consumed during flight, the aircraft's mass and CG change. To calculate the effect, convert the amount of fuel used from US gallons to pounds using the specific gravity (e.g., 0.72). Subtract the used fuel from the initial fuel to find the remaining fuel mass, then recalculate the moment and CG.

- **Keypoints**
  - Convert US gallons to pounds using specific gravity (e.g., 10 US gallons × 0.72 = 7.2, then use conversion chart to get pounds)
  - Subtract used fuel from initial fuel to get remaining fuel mass
  - Recalculate moment and CG after fuel consumption
- **Explanation**
  For example, if 10 US gallons of fuel are forecast to be used, convert to pounds (using 0.72 specific gravity, 10 US gallons ≈ 60 pounds). Subtract from initial fuel to get remaining fuel. Calculate the new moment for the remaining fuel and update the total moment and CG.
- **Examples**
  > If 10 US gallons of fuel are used, and specific gravity is 0.72, convert to pounds (10 × 0.72 = 7.2, then use chart to get 60 pounds). Subtract 60 pounds from initial fuel to get remaining fuel. Calculate the new moment for 100 pounds of fuel (e.g., 100 × 25.3 = 2,530). Subtract the moment of used fuel from the takeoff moment to get landing moment.

  - Convert 10 US gallons to pounds using specific gravity and conversion chart (result: 60 pounds).
  - Subtract 60 pounds from initial fuel to get remaining fuel (e.g., 160 - 60 = 100 pounds).
  - Calculate moment for remaining fuel (e.g., 100 × 25.3 = 2,530).
  - Subtract moment of used fuel from takeoff moment to get landing moment.
- **Considerations**
- Always use the correct specific gravity for the fuel type.
- Double-check unit conversions between gallons and pounds.
- **Special Circumstances**
- If the aircraft is close to CG or weight limits, fuel consumption may move it out of limits during flight; plan accordingly.

Overloading and Its Consequences

> Overloading an aircraft can have serious consequences, including exceeding structural limits and moving the CG out of safe limits. Calculations must be performed to predict the CG at the end of the flight, especially after fuel consumption.

- **Keypoints**
  - Overloading can cause the aircraft to be outside safe CG and weight limits
  - CG must be recalculated after fuel is used
  - If overloaded, adjust load or fuel before flight
- **Explanation**
  Given a loading sheet and a forecast of fuel usage, calculate the CG at the end of the flight by subtracting the mass and moment of used fuel from the initial values. If the aircraft is overloaded or CG is out of limits, corrective action must be taken.
- **Examples**
  > If the aircraft starts with a certain mass and moment, and 10 US gallons (60 pounds) of fuel are used, subtract the mass and moment of the used fuel from the initial values to find the CG at landing.

  - Calculate the mass and moment of used fuel.
  - Subtract from initial mass and moment.
  - Divide new moment by new mass to find CG at landing.
  - Check if CG and weight are within limits.
- **Considerations**
- Never attempt flight if the aircraft is overloaded or CG is out of limits.
- Always recalculate CG after significant fuel consumption.
- **Special Circumstances**
- If encountering overloading, remove payload or reduce fuel to bring the aircraft within safe limits.

Calculation of Center of Gravity (CG) at Landing

> The process of determining the CG location at landing involves dividing the total moment by the landing mass. This is essential for ensuring the aircraft remains within safe operational limits.

- **Keypoints**
  - CG at landing = Total moment at landing / Landing mass
  - Example: 112,000 (moment) / 2,000 (mass) = 56.2 (CG location)
  - CG location must be checked against aircraft category limits (e.g., utility category)
- **Explanation**
  The instructor demonstrates how to calculate the CG at landing by dividing the total moment by the landing mass. The result is then compared to the allowable CG range for the utility category. If the CG falls outside the permitted range, the aircraft is not within safe operational limits.
- **Examples**

> Given a moment of 112,000 and a landing mass of 2,000, the CG at landing is calculated as 112,000 / 2,000 = 56.2. This value is then compared to the utility category limits (e.g., 56.7). If the CG is within the range, the aircraft is safe to operate.

  - Identify the total moment at landing (112,000).
  - Identify the landing mass (2,000).
  - Divide the moment by the mass to get the CG location (56.2).
  - Compare the CG location to the utility category limits (e.g., 56.7).
- **Considerations**
- Always use exact numbers as provided; do not round or estimate.
- Check the CG location against the correct category limits.
- **Special Circumstances**
- If the CG falls outside the permitted range, the aircraft must be reloaded or the load adjusted to bring the CG within limits.

Aircraft Mass and Weight Definitions

> Key definitions for aircraft mass and weight categories, including MTOM, MTOW, MZFM, LRM, and MTMA, as well as the distinction between mass and weight in aviation.

- **Keypoints**
  - MTOM (Maximum Takeoff Mass): Maximum mass permitted for takeoff.
  - MTOW (Maximum Takeoff Weight): Sometimes used interchangeably with MTOM.
  - MZFM (Maximum Zero Fuel Mass): Total mass including passengers, baggage, and unusable fuel, but not usable fuel.
  - LRM (Maximum Ramp Mass): Maximum mass of the parked aircraft, accounting for fuel used during taxi.
  - MTMA: Sometimes referred to as Maximum Total Mass after design.
  - Mass and weight are often used interchangeably, but in aviation, mass is measured in kilograms or pounds, not newtons.
- **Explanation**
  The instructor explains the definitions and differences between various mass and weight categories, emphasizing the importance of using the correct terminology and understanding what each category includes or excludes. The distinction between mass (kg/lb) and weight (force) is highlighted, as well as the use of these terms in official documents and exams.
- **Examples**
  > An aircraft’s load sheet lists the mass as 3,600 pounds or 1,633 kilograms. This is the MTOM/MTOW, not the force in newtons.

- Check the load sheet for the listed mass.
    - Understand that the value refers to mass, not force.
    - Use the correct units (kg or lb) in calculations and documentation.
- **Considerations**
- Always refer to the aircraft's manual (Section 5) for performance data.
- Be aware of the terminology used in different documents and exams.
- **Special Circumstances**
- If encountering unfamiliar terminology (e.g., MTMA), refer to the Aircraft Certificate Airworthiness or official exam guidelines for clarification.

Aircraft Loading Categories and Formulas

> Understanding the categories of aircraft mass (BAM, DOM, Traffic Load, Useful Load) and the formulas used to calculate traffic load and useful load.

- **Keypoints**
    - Basic Empty Mass (BAM): Mass of the aircraft including all basic equipment.
    - Dry Operating Mass (DOM): Total mass of the airplane ready for a specific operation, excluding usable fuel and traffic load.
    - Traffic Load: Total mass of passengers, baggage, cargo, and any non-revenue load.
    - Useful Load: Total mass of passengers, baggage, cargo (including non-revenue load), and usable fuel.
    - Formula for Traffic Load: Traffic Load = Zero Fuel Mass - Dry Operating Mass
    - Formula for Useful Load: Useful Load = Traffic Load + Usable Fuel
- **Explanation**
  The instructor provides definitions for each mass category and explains how to calculate traffic load and useful load using the provided formulas. Examples of non-revenue load are given, such as company crew or technical parts transported without profit.
- **Examples**
  > Given a zero fuel mass and a dry operating mass, the traffic load is calculated by subtracting the dry operating mass from the zero fuel mass.

    - Identify the zero fuel mass.
    - Identify the dry operating mass.
    - Subtract the dry operating mass from the zero fuel mass to get the traffic load.
- **Considerations**
- Write down all definitions and formulas for exam preparation.
- Include non-revenue loads in traffic load calculations.
- **Special Circumstances**

- If the dry operating mass is not provided in the exam materials, write it in your notes for reference.

Responsibility for Aircraft Loading

> The final responsibility for ensuring the aircraft is loaded within limits always rests with the aircraft commander, regardless of input from other parties.

- **Keypoints**
  - Aircraft commander is responsible for checking and signing the load sheet.
  - Responsibility cannot be delegated to co-pilot, owner, operator, handling agent, or load master.
  - Load sheet includes mass of the aircraft and CG location table.
  - In multi-crew operations, the captain signs off after verifying all limits are respected.
- **Explanation**
  The instructor emphasizes that, regardless of the size of the aircraft or the number of crew members, the aircraft commander (or captain) is ultimately responsible for verifying that the aircraft is loaded correctly and within all specified limits. This includes checking the load sheet and CG location before signing off.
- **Examples**
  > In a multi-crew jet, the captain checks the load sheet, verifies all masses and CG locations are within limits, signs the document, and returns it to the load master.

  - Review the load sheet for all relevant data.
  - Compare actual values to specified limits.
  - Sign the load sheet only if all values are within limits.
- **Considerations**
- Never sign a load sheet without verifying all data.
- Responsibility remains with the commander even if others have prepared the documentation.
- **Special Circumstances**
- If a discrepancy is found in the load sheet, the commander must resolve it before signing and proceeding with the flight.

Impact of Loading on Aircraft Performance

> Improper or excessive loading can negatively affect aircraft performance, including takeoff, climb, landing speeds, and distances.

- **Keypoints**
  - Overweight or overloaded aircraft require higher approach and landing speeds.

- Landing distances are increased with higher mass.
    - Climb performance may be insufficient to clear obstructions.
    - Aircraft stability and control forces are affected by CG position.
    - Loading outside specified limits can compromise safety.
- **Explanation**
  The instructor discusses how improper loading, especially exceeding maximum mass or incorrect CG position, can lead to increased landing speeds and distances, reduced climb performance, and potentially unsafe flight characteristics. The importance of adhering to specified limits is stressed.
- **Examples**
  > An aircraft loaded above its maximum takeoff mass will require a longer runway for takeoff and landing, may not be able to climb over obstacles, and could be unsafe to operate.

    - Check actual mass against maximum permitted values.
    - Understand the operational consequences of exceeding limits.
    - Take corrective action (unload or redistribute weight) if limits are exceeded.
- **Considerations**
- Always check mass and CG before flight.
- Understand the operational impact of loading decisions.
- **Special Circumstances**
- If the aircraft is found to be overloaded, remove excess weight before attempting flight.

Conversions and Reference Materials

> Use of conversion tables and reference materials is essential for accurate calculations, especially in exams and operational settings.

- **Keypoints**
    - To convert pounds to kilograms, multiply by 0.454.
    - Reference materials such as CAP 696 and aircraft manuals provide necessary definitions and tables.
    - Section 5 of the aircraft manual contains performance data; Section 3 contains emergency procedures.
- **Explanation**
  The instructor advises students to use conversion tables and reference materials during exams and flight planning. Specific conversion factors and the location of key information in manuals are highlighted.
- **Examples**

> If the mass is given in pounds, multiply by 0.454 to obtain the value in kilograms.

  - Identify the mass in pounds.
  - Multiply by 0.454 to convert to kilograms.
- **Considerations**
- Print out necessary reference materials for exams.
- Know where to find key information in manuals.
- **Special Circumstances**
- If a conversion value is forgotten during the exam, refer to the printed conversion table.

CFP5 Computer and Unit Conversion

> The CFP5 computer is used for converting various units such as pounds to kilograms, miles, feet, gallons, liters, etc. The process involves aligning specific values on the computer's scales and reading the corresponding converted value on the movable circle.

- **Keypoints**
  - Locate the unit to convert from (e.g., pounds) on the CFP5 computer.
  - Align the given value (e.g., 160) with the arrow or marker.
  - Find the target unit (e.g., kilograms) and read the value on the movable circle.
  - Specific gravity may be used for certain conversions (e.g., pounds to kilograms with a specific gravity of 0.72).
  - Mental estimation checks are encouraged (e.g., 1 imperial gallon ≈ 10 pounds).
- **Explanation**
  For example, to convert 160 pounds to kilograms: locate 'LBS' on the right side, align 160 with the arrow, then find kilograms and read the value (72.5 kg). For 80 pounds, the answer is 36.5 kg. For conversions involving specific gravity, align the value with the arrow, select the specific gravity (e.g., 0.72), and read the corresponding value.
- **Examples**
  > Align 160 on the pounds scale with the arrow, then find kilograms on the inner movable circle. The answer is 72.5 kilograms.

  - Locate 'LBS' on the right side of CFP5.
  - Align 160 with the arrow using the red marker for precision.
  - Find 'kilograms' on the scale.
  - Read the value below kilograms: 72.5 kg.
  > Align 80 on the pounds scale, find kilograms, and read the value: 36.5 kilograms.

    - Align 80 with the arrow.
    - Find kilograms on the scale.
    - Read the value: 36.5 kg.
- **Considerations**
- Always double-check alignment for accuracy.
- Use mental estimation as a check against calculation errors.
- Be aware of specific gravity when converting between mass and volume.
- **Special Circumstances**
- If the specific gravity is not standard (e.g., not 1.0), ensure to select the correct value on the CFP5.

Center of Gravity (CG) in Aircraft

> The center of gravity is the point where all the mass of the aircraft is concentrated and about which the aircraft balances. The CG position is affected by the placement of mass within the aircraft, and it is critical for safe and stable flight.

- **Keypoints**
    - CG is the point where all the weight acts.
    - CG position changes with loading and unloading of items.
    - Each item loaded affects both total mass and CG position.
    - Moment is calculated as weight x lever arm (distance from datum).
    - CG must remain within specified forward and rearward limits for safe operation.
    - Forward CG increases stability but reduces performance (increased stall speed, drag, takeoff/landing distance, fuel consumption).
    - Rearward CG decreases stability but increases performance (decreased stall speed, drag, increased range and climb rate).
    - CG outside limits can cause loss of control or crash.
- **Explanation**
  To find CG, sum all moments (weight x arm) for each item, then divide by total mass. For example, a 100 kg block placed 60 cm from the datum gives a moment of 6,000 kg-cm. If the same block is placed 100 cm away, the moment is 10,000 kg-cm. The CG location is then calculated and compared to aircraft limits.
- **Examples**
  > A 100 kg block is placed 60 cm from the datum. The moment is 6,000 kg-cm. If moved to 100 cm, the moment becomes 10,000 kg-cm.

    - Moment = weight x arm = 100 kg x 60 cm = 6,000 kg-cm.
    - If arm is 100 cm: 100 kg x 100 cm = 10,000 kg-cm.
    - Sum all moments and divide by total mass to find CG location.
- **Considerations**

- Always ensure CG is within specified limits before flight.
- Place items as close to the CG as possible to minimize their effect.
- Be aware that even small items far from CG can have a large effect.
- **Special Circumstances**
- If CG is outside the rearward limit, the nose may lift before takeoff speed, risking tail strike or loss of control.
- If CG is outside the forward limit, increased control forces and takeoff/landing distances may occur.

Effects of Wind on Aircraft Performance

> Wind affects ground speed and distance traveled. Tailwind increases ground speed and distance, while headwind decreases them. The triangle method is used to calculate wind correction angles and resulting ground speed.

- **Keypoints**
  - Tailwind increases ground speed and distance covered in a given time.
  - Headwind decreases ground speed and distance.
  - Wind correction angle is calculated using the triangle method.
  - Ground speed is the vector sum of airspeed and wind speed.
- **Explanation**
  For example, with 80 knots airspeed and 6 minutes of flight, a tailwind allows more distance to be covered (e.g., 3.75 miles instead of 3 miles). The triangle method is used to draw and calculate the effect of wind on the flight path.
- **Examples**
  > With 80 knots airspeed and 6 minutes, tailwind increases distance from 3 miles to 3.75 miles.

  - Calculate distance without wind: 80 knots x 6/60 = 8 miles.
  - With tailwind, ground speed increases, so more distance is covered.
  - Use triangle method to determine wind correction angle and new ground speed.
- **Considerations**
- Always account for wind when planning flight distance and fuel requirements.
- Use mental checks to verify calculations.
- **Special Circumstances**
- If strong tailwind, ensure runway length is sufficient for increased landing distance.
- If strong headwind, ensure fuel reserves are adequate for reduced ground speed.

Mass and Balance Sheet Practice

> Practical exercises using the mass and balance sheet are essential for understanding aircraft loading, CG calculation, and ensuring safe operation.

- **Keypoints**
  - Practice with real data to reinforce calculation methods.
  - Use SOP (Standard Operating Procedures) for consistency.
  - Sum all moments and divide by total mass to find CG.
- **Explanation**
  Students are encouraged to practice mass and balance calculations using real aircraft data and the provided sheets, following SOPs.
- **Considerations**
- Always use up-to-date data for calculations.
- Double-check all entries and calculations for accuracy.

System Failure and Continued Motion

> In the event of a system failure, the aircraft or vehicle may continue to move or function for a period before coming to a stop or ceasing operation.

- **Keypoints**
  - System failure does not result in immediate cessation of motion.
  - Residual motion or function may persist after failure.
- **Considerations**
- Be prepared for continued motion after a failure and plan accordingly.
- **Special Circumstances**
- If a system fails, monitor for continued motion and take appropriate action to bring the vehicle to a safe stop.

Temperature and Condition Calculations at Altitude

> The lecture discusses how to calculate temperature or condition values at different altitudes, using specific numbers and mathematical operations. For example, the difference in degrees, division of values, and resulting conditions at 2,000 meters and 1,000 meters.

- **Keypoints**
  - At 2,000 meters, the condition is 11 degrees.
  - At 1,000 meters, the condition is calculated as 2,000 meters divided by 1,000, resulting in 12 degrees.
  - A real value adjustment is made: plus 9, resulting in a value greater than 11 divided by 9, which is 20.
  - Condition at 1,000 is 2,000 meters, which is 6.25.

- **Explanation**
  The speaker walks through a series of calculations involving altitude and temperature or condition values. For example, starting with 2,000 divided by 1,000 to get 12 degrees, noting that at 2,000 meters the condition is 11, and then adjusting with a plus 9 to get a value greater than 11 divided by 9, which is 20. The condition at 1,000 is also calculated as 2,000 meters, resulting in 6.25.
- **Examples**
  > At 2,000 meters, the condition is 11 degrees. When dividing 2,000 by 1,000, the result is 12 degrees. Adjusting with plus 9, the value becomes greater than 11 divided by 9, which is 20.

  - Start with 2,000 meters.
  - Divide 2,000 by 1,000 to get 12.
  - At 2,000 meters, the condition is 11.
  - Add 9 to the real value, making it greater than 11 divided by 9.
  - Result is 20.
- **Considerations**
- Ensure all numerical values are used exactly as stated.
- Adjustments (such as plus 9) must be applied as described.

Use of Premium Figures in Production

> The process of creating premium figures involves the use of premium figures themselves, as stated in the Japanese segment.

- **Keypoints**
  - Premium figures are used to make premium figures.
- **Explanation**
  The Japanese segment repeats that premium figures are used in the production of premium figures, emphasizing the use of high-quality materials or models in the creation process.

Computer Crashing and Security

> Discussion about the ability to crash or break computers, including PCs, MacBooks, and Linux systems, and the need for specific keys or remote access.

- **Keypoints**
  - Any PC, including Mac and Linux, can be crashed.
  - A remote key or PS key may be needed to perform certain actions.
  - Physical damage is not possible, but software-based crashing is discussed.
- **Explanation**
  The conversation covers the possibility of crashing computers, with the speaker

claiming that any PC, including MacBooks and Linux systems, can be crashed. However, actual physical damage is not possible, and some actions may require a remote key or PS key.

- **Considerations**
- Distinguish between software crashing and physical damage.
- Some actions require specific keys or remote access.
- **Special Circumstances**
- If encountering a system that requires a remote key or PS key, ensure you have the necessary access before attempting to control or crash the device.

Personal Routines and Scheduling

> Discussion about dinner times and personal energy levels, with specific times mentioned (6, 10, 4pm, 10pm).

- **Keypoints**
  - 6 is dinner time.
  - 10 is considered too late for dinner.
  - From 4pm till 10pm, the speaker would be ‘literally dead’.
- **Explanation**
  The speaker discusses their personal routine, stating that 6 is the preferred dinner time, while 10 is too late. They emphasize that by 10pm, or even from 4pm to 10pm, they would be exhausted.
- **Considerations**
- Personal schedules and energy levels should be considered when planning activities.