

## FLIGHT PERFORMANCE AND PLANNING (1) MASS AND BALANCE

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- 1 The centre of gravity of an aircraft
- A is in a fixed position and is unaffected by aircraft loading.
  - B must be maintained in a fixed position by careful distribution of the load.
  - C can be allowed to move between defined limits.
  - D may only be moved if permitted by the regulating authority and endorsed in the aircraft's certificate of airworthiness.
- 2 During take-off you notice that, for a given elevator input, the aeroplane rotates much more rapidly than expected. This is an indication that:
- A the aeroplane is overloaded.
  - B the centre of gravity may be towards the aft limit.
  - C the centre of pressure is aft of the centre of gravity.
  - D the centre of gravity is too far forward.
- 3 The floor limit of an aircraft cargo hold is 5 000 N/m<sup>2</sup>. It is planned to load-up a cubic container measuring 0,4 m of side. It's maximum gross mass must not exceed: (assume  $g=10\text{m/s}^2$ )
- A 80 kg
  - B 800 kg
  - C 32 kg
  - D 320 kg
- 4 An aeroplane is weighed and the following recordings are made:
- |                                 |          |
|---------------------------------|----------|
| nose wheel assembly scale       | 5330 kg  |
| left main wheel assembly scale  | 12370 kg |
| right main wheel assembly scale | 12480 kg |
- If the 'operational items' amount to a mass of 1780 kg with a crew mass of 545 kg, the empty mass, as entered in the weight schedule, is
- A 32505 kg
  - B 31960 kg
  - C 28400 kg
  - D 30180 kg
- 5 The take-off mass of a helicopter is 8600 kg which includes a traffic load of 1890 kg and a usable fuel load of 1230 kg. If the standard mass for the crew is 190 kg the dry operating mass is
- A 5290 kg
  - B 5480 kg
  - C 8410 kg
  - D 6710 kg
- 6 The zero fuel mass of an aeroplane is always:
- A The maximum take-off mass minus the take-off fuel mass.
  - B The take-off mass minus the fuselage fuel mass.
  - C The take-off mass minus the wing fuel mass.
  - D The take-off mass minus the take-off fuel mass.

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- 7 The standard mass for a child is
- A 35 kg for holiday charters and 38 kg for all other flights.
  - B 35 kg for all flights.
  - C 30 kg for holiday charters and 35 kg for all other flights.
  - D 38 kg for all flights.
- 8 The Traffic Load is defined as:
- A The total mass of flight crew, passengers, baggage, cargo and usable fuel
  - B The total mass of crew and passengers excluding any baggage or cargo
  - C The total mass of passengers, baggage and cargo, including any non revenue load
  - D The total mass of passengers, baggage, cargo and usable fuel
- 9 Given:
- |                                  |           |
|----------------------------------|-----------|
| Dry Operating Mass=              | 29 800 kg |
| Maximum Take-Off Mass=           | 52 400 kg |
| Maximum Zero-Fuel Mass=          | 43 100 kg |
| Maximum Landing Mass=            | 46 700 kg |
| Trip fuel=                       | 4 000 kg  |
| Fuel quantity at brakes release= | 8 000 kg  |
- The maximum traffic load is:
- A 13 300 kg
  - B 12 900 kg
  - C 14 600 kg
  - D 9 300 kg
- 10 In centre of gravity calculations the datum is
- A The fixed reference about which moments are taken to calculate the position of the centre of pressure
  - B The fixed reference about which moments are taken to calculate the position of the centre of gravity
  - C The horizontal reference used to calculate the helicopter's empty centre of gravity
  - D The point through which the centre of gravity acts

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**MASS AND BALANCE**

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- 11 The mass and balance information gives:  
Basic mass: 1 200 kg ; Basic balance arm: 3.00 m

Under these conditions the Basic centre of gravity is at 25% of the mean aerodynamic chord (MAC). The length of MAC is 2m.

In the mass and balance section of the flight manual the following information is given:

Position Arm  
front seats: 2.5 m  
rear seats: 3.5 m  
rear hold: 4.5 m  
fuel tanks: 3.0 m

The pilot and one passenger embark; each weighs 80 kg. Fuel tanks contain 140 litres of petrol with a density of 0.714. The rear seats are not occupied. Taxi fuel is negligible. The position of the centre of gravity at take-off (as % MAC) is:

- A 34 %
  - B 17 %
  - C 22 %
  - D 29 %
- 12 (For this question use annex A)  
Using the data given in the Load & Trim sheet, determine which of the following gives the correct values for the Zero Fuel Mass and position of the centre of gravity (% MAC) at that mass.
- A 51300 Kg and 20,8%
  - B 46130 Kg and 20,8%
  - C 46130 Kg and 17,8%
  - D 41300 Kg and 17,8%



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### MASS AND BALANCE

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#### Answers to Sample Questions

1. The CG can move within defined limits, Answer C. The last answer might also be considered correct because the range of the CG positions is part of the C of A information endorsed by the regulating Authority. On balance, we think D was intended as a spoof answer.
2. A CG at the aft limit will result in reduced longitudinal static stability, this means it is easy to displace in pitch which means that for a given control force it will pitch more rapidly. An overloaded aircraft would be closer to the stall, but could be stable or unstable, a forward CG would make the pitch forces greater and the CP is usually behind the CG. Answer B
3. The contact area of the container is  $0.4\text{m} \times 0.4\text{m} = 0.16\text{m}^2$ . If 5000N can be spread over  $1\text{m}^2$  then a reduced force of  $5000 \times 0.16 = 800\text{N}$  would be permitted over  $0.16\text{m}^2$ . Using the conversion factor of  $g=10\text{m/s}^2$ , which means the same as  $10\text{N} = 1\text{kg}$ , 800N is 80kg, Answer A.
4. Empty mass does not include 'operational items' or crew so total the weights on the wheels,  $5330 + 12370 + 12480 = 30,180$ . Answer D
5.  $\text{DOM} = \text{AUM} - \text{Traffic load} - \text{Fuel} = 8600 - 1890 - 1230 = 5480\text{kg}$ . Answer B
6. ZFM is the TOM minus the (usable) take-off fuel mass. There being no exactly correct answer, Answer D.
7. Standard masses are not asked in the UK exams. In this case the answer is 35kg.
8. Traffic load is defined on page 2 of the CAP, Answer C
9. Create a table.....

	TO	ZF	LDG
Limit	52 400	43 100	46 700
- DOM	29 800	29 800	29 800
- Fuel	8 000	-	4 000
= Traffic load	14 600	13 300	12 900

Answer B

10. Answer B
11. The given data means that the aircraft empty CG is 3m aft of the datum at 25% MAC. Create a table:

Position	Weight	Arm	Moment
Basic Aircraft	1200 kg	3.00	3600 kgm
Front Seats	160 kg	2.50	400 kgm
Rear Seats		3.50	
Rear Hold		4.50	
Fuel Tanks	100 kg	3.00	300 kgm
Totals	<b>1460 kg</b>		<b>4300 kgm</b>

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The CG position is  $\text{moment} \div \text{mass} = 4300 \div 1460 = 2.945\text{m}$  aft.

Now to convert to %MAC.

The BEM had a CG at 25%MAC on a 2m chord, and this was also 3m aft of the datum. 25% of 2m is 50cm or 0.5m so the leading edge of the MAC has to be 2.5m aft of the datum. The CG position at take-off is  $2.945 - 2.5 = 0.445\text{m}$  aft of the leading edge of the MAC. The percentage MAC is therefore  $0.445 \div 2 = 22.26\%MAC$ . Answer C.

This should be a high scoring question, at least 4 marks.

12. The easiest thing to do is to identify the DOM and Traffic Load from the left hand side. DOM is 34900kg, Traffic Load 11230kg. Add them to find the ZFM, 46130kg. Draw a horizontal line at this mass across the CG envelope at the bottom right of the Annex to represent the ZFM.

Now you need to trace through the grids at the top right of the Annex starting from the DOM index of 33.5. Make no correction for fuel index and drop down to cross the line that represents the ZFM. We get 46130kg and CG at about 17.6%MAC, Answer C.

