3.15 Pressure, Moments and Levers: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A weather balloon is released from the ground and rises to a very high altitude. Explain why atmospheric pressure decreases as altitude increases, and why the rate of decrease is not constant (atmospheric pressure decreases more quickly at low altitudes than at high altitudes).

(Total for Question 1 is 6 marks)

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2 Higher tier only. A steel ball bearing sinks when placed in water, but a large steel ship floats, even though the ship is far heavier than the ball bearing. Both the ball bearing and the ship experience an upthrust force from the water.

(a) State the condition, in terms of weight and upthrust, for an object to float in a fluid. **(1)**

(b) State how the upthrust on a submerged (or partly submerged) object is related to the weight of fluid it displaces. **(1)**

(c) Explain why the ball bearing sinks, while the ship floats, in terms of the volume of water each displaces. **(2)**

(Total for Question 2 is 4 marks)

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3 A mechanic, Priya, needs to loosen a stiff bolt. The moment needed to loosen the bolt is 18 Nm. She can apply a maximum force of 90 N with her hand. Use the equation moment = force x perpendicular distance.

(a) Calculate the minimum perpendicular distance from the bolt at which Priya must apply this force to loosen it. **(2)**

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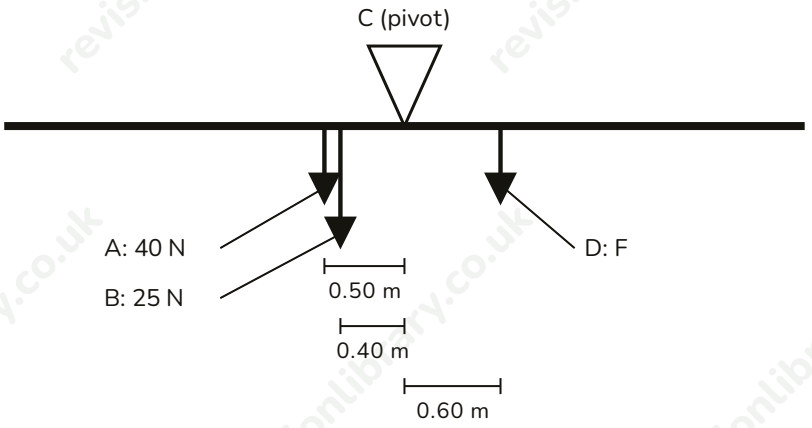
(b) Priya then fits an extension bar to her spanner, which doubles the perpendicular distance at which she can apply her force. Calculate the minimum force she now needs to apply to produce the same 18 Nm moment. **(2)**

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(Total for Question 3 is 4 marks)

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4 Figure 3 shows a uniform beam, pivoted at its centre, C. Two forces act downwards on the left of the pivot: 40 N at point A, 0.50 m from C, and 25 N at point B, 0.40 m from C. A single downward force, F, acts at point D, 0.60 m to the right of C. The beam is in equilibrium.



(a) Calculate the total moment produced by the two forces on the left of the pivot. **(3)**

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(b) Use the principle of moments to calculate F. **(2)**

.....

(c) State what is meant by the beam being 'in equilibrium'. **(1)**

(Total for Question 4 is 6 marks)

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5 A tractor's wheel exerts a force of 6000 N on the ground. The area of the wheel in contact with the ground is 0.50 m^2. Use the equation pressure = force / area (p = F / A).

(a) Define pressure. **(1)**

(b) State the equation linking pressure, force and area, and state the unit of pressure. **(2)**

(c) Calculate the pressure the wheel exerts on the ground. **(2)**

(Total for Question 5 is 5 marks)

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Mark scheme · 3.15 Pressure, Moments and Levers: 30-minute Pack

Question 1

Level 1 One or two isolated, correct statements are made, for example that atmospheric pressure decreases with height, with little or no reference to air molecules, weight of air, or density. **1-2**

Level 2 Identifies that there is less air (fewer air molecules, and less weight of air) above a point as altitude increases, and links this to fewer collisions and a decrease in pressure, but does not explain why the rate of decrease changes with altitude. **3-4**

Level 3 A clear, logically sequenced explanation: as altitude increases, there is less air (fewer molecules, less weight of air) above a given point, so fewer/weaker collisions occur per second and pressure decreases; and explains that because the atmosphere is denser near the ground, a small increase in height near sea level removes a relatively large amount of air, so pressure falls quickly at low altitude, whereas at high altitude the air is already thin, so climbing further removes much less air, so pressure falls more slowly. **5-6**

Indicative content:

- atmospheric pressure at a point is caused by the weight of the column of air above that point
- as altitude (height) increases, there is less air (fewer air molecules) above a given point
- this means the weight of air above the point decreases as altitude increases
- fewer air molecules also means fewer collisions between air molecules and a surface per second
- pressure is force per unit area, so fewer or weaker collisions per second means lower pressure
- the atmosphere becomes less dense with increasing height (the air itself gets thinner)
- because the air is much denser near sea level, a small increase in height near the ground removes a relatively large amount of air (and weight) from above the point, so pressure decreases quickly at low altitude
- at high altitude the air is already thin, so the same increase in height removes much less mass of air, so pressure decreases more slowly
- therefore atmospheric pressure decreases with height, but not at a constant rate; it decreases increasingly slowly as altitude increases

Question 2

(a) an object floats when the upthrust acting on it is equal to its weight, oe **B1**

(a) Answer: An object floats when the upthrust on it equals its weight.

(b) the upthrust is equal to the weight of fluid displaced by the object, oe **B1**

(b) Answer: The upthrust is equal to the weight of fluid displaced.

(c) the ball bearing has a small volume, so it displaces only a small weight of water, giving a small upthrust that is less than its weight, so it sinks, oe **B1**

(c) the ship's hull has a very large volume (much of it filled with air), so it displaces a very large weight of water, giving an upthrust large enough to equal its (much greater) weight, so it floats, oe **B1**

(c) Answer: The ball bearing displaces little water, so its upthrust is less than its weight and it sinks. The ship's large hull displaces enough water to give an upthrust equal to its weight, so it floats.

Question 3

(a) rearranges and substitutes: distance = 18 / 90 **M1**

(a) 0.20 m cao **A1**

(a) Answer: 0.20 m

(b) ft new distance = 2 x their (a) = 0.40 m; rearranges: force = 18 / 0.40 **M1**

(b) 45 N cao ft **A1**

(b) Answer: 45 N

Question 4

(a) moment of 40 N force = 40 x 0.50 = 20 Nm **M1**

(a) moment of 25 N force = 25 x 0.40 = 10 Nm **M1**

(a) total = 30 Nm (20 + 10) cao **A1**

(a) Answer: 30 Nm

(b) ft rearranges: F = their (a) / 0.60 **M1**

(b) 50 N cao ft **A1**

(b) Answer: 50 N

(c) the resultant force and the resultant (net) moment on the beam are both zero, so it does not move or turn, oe **B1**

(c) Answer: The resultant force and resultant moment on the beam are both zero.

Question 5

(a) the force acting per unit area (normal to a surface), oe **B1**

(a) Answer: The force acting per unit area, at right angles to a surface.

(b) pressure = force / area, accept p = F / A **B1**

(b) unit: pascal (Pa), accept N/m^2 **B1**

(b) Answer: Pressure = force / area. Unit: pascal (Pa), equivalent to N/m^2.

(c) substitutes: p = 6000 / 0.50 **M1**

(c) 12000 Pa cao **A1**

(c) Answer: 12000 Pa

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