Questions on Forces

1. The figure below shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at A.

![Diagram of a cupboard mounted to a wall with a support at A, a screw, and the line of action of the weight at 12 cm from A, and the wall at 75 cm from A.]

The total weight of the cupboard and its contents is 200 N. The line of action of its weight is at a distance of 12 cm from A. The screw securing the cupboard to the wall is at a vertical distance of 75 cm from A.

(i) State the principle of moments.

_In your answer, you should use appropriate technical terms, spelled correctly._

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[2]
(ii) The direction of the force \( F \) provided by the screw on the cupboard is horizontal as shown in the figure above. Take moments about \( A \). Determine the value of \( F \).

\[ F = \text{...................................................... N} \]

[2]

(iii) The cross-sectional area under the head of the screw in contact with the cupboard is \( 6.0 \times 10^{-5} \text{ m}^2 \). Calculate the pressure on the cupboard under the screw head.

\[ \text{pressure} = \text{..................................................... Pa} \]

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(iv) State and explain how your answer to (iii) would change, if at all, if the same screw was secured much closer to \( A \).

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[Total 8 marks]
2. The figure below shows a lawn mower which is carried by two people.

(i) The two people apply forces \( A \) and \( B \) at each end of the lawn mower. The weight of the lawn mower is 350 N.

1. Explain why the weight of the lawn mower does not act in the middle of the lawn mower, that is 55 cm from each end.

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[1]

2. Use the principle of moments to show that the force \( B \) is 64 N.

[2]

3. Determine the force \( A \).

\[ A = \ldots \ldots \ldots \ldots \ldots \ldots N \]

[1]
(ii) State and explain what happens to the forces $A$ and $B$ if the person that applies force $B$ moves his hands along the handle towards the middle of the lawn mower.

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[2]
[Total 6 marks]
3. The figure below shows a uniform rectangular beam supported by two straps. The beam is in equilibrium.

The weight of the beam is 3600 N and its length is 4.0 m. The strap A is positioned 0.50 m from one end of the beam and the strap B is positioned 1.0 m from the other end.

(i) Use the principle of moments to show that the upward force $X$ at strap A is 1440 N.

(ii) Discuss whether the forces $X$ and $Y$ provide a couple.

\[ \text{force} = \ldots \ldots \ldots \ldots \ldots \ldots \ \text{N} \]
(iii) The area of strap A in contact with the underside of the beam is $2.3 \times 10^{-2}$ m². Calculate the average pressure exerted on the beam by strap A.

\[
\text{pressure} = \text{.............................. unit ..............................} \quad [3]
\]

[Total 9 marks]

4. Define the newton.

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[Total 1 mark]

5. A car of mass 1380 kg, travelling at 31.1 m s⁻¹, is brought to rest by the brakes in 48.2 m. Calculate

(i) the initial kinetic energy of the car

\[
\text{kinetic energy} = \text{.............................. J} \quad [3]
\]

(ii) the average deceleration of the car

\[
\text{deceleration} = \text{.............................. m s}^{-2} \quad [2]
\]
6. Describe in terms of the forces acting on the driver how wearing a seat belt and having an airbag in a car can help to protect the driver from injury in a head-on collision.

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[Total 4 marks]

7. State two factors that affect the braking distance of a car. Describe how each factor affects the braking distance.

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[Total 4 marks]
8. Describe how Global Positioning System (GPS) is used to locate the position of a car on the Earth's surface.

In your answer, you should use appropriate technical terms, spelled correctly.

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[Total 4 marks]

9. The figure below shows two masses A and B tied to the ends of a length of string. The string passes over a pulley. The mass A is held at rest on the floor.

The mass A is 1.20 kg and the mass B is 1.50 kg.
(a) Calculate the weight of mass B.

\[ \text{weight} = \frac{\text{mass} \times g}{1} \text{ N} \]

(b) Mass B is initially at rest at a height of 2.80 m above the floor. Mass A is then released. Mass B has a constant downward acceleration of 1.09 m s\(^{-2}\). Assume that air resistance and the friction between the pulley and the string are negligible.

(i) In terms of forces, explain why the acceleration of the mass B is less than the acceleration of free fall g.

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(ii) Calculate the time taken for the mass B to fall 1.40 m.

\[ \text{time} = \frac{\text{distance}}{\text{acceleration}} \text{ s} \]

(iii) Calculate the velocity of mass B after falling 1.40 m.

\[ \text{velocity} = \frac{\text{distance}}{\text{time}} \text{ m s}^{-1} \]
(iv) Mass \( B \) hits the floor at a speed of 2.47 m s\(^{-1} \). It **rebounds** with a speed of 1.50 m s\(^{-1} \). The time of contact with the floor is \( 3.0 \times 10^{-2} \) s. Calculate the magnitude of the average acceleration of mass \( B \) during its impact with the floor.

\[
\text{acceleration} = \cdots \quad \text{m s}^{-2}
\]

[2]

[Total 9 marks]

10. State why the equation ‘\( F = ma \)’ cannot be applied to particles travelling at speeds very close to the speed of light.

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[Total 1 mark]

11. The figure below shows a ship \( S \) being pulled by two tug-boats.

The ship is travelling at a constant velocity. The tensions in the cables and the angles made by these cables to the direction in which the ship travels are shown in the figure above.
(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = .................................................... kN

(ii) State the value of the drag force acting on the ship S. Explain your answer.

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[Total 5 marks]

12. Describe an experiment to determine the centre of gravity of the metal plate shown in the figure below.

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13. The figure below shows the horizontal forces acting on a car of mass 900 kg when it is travelling at a particular velocity on a level road.

The total forward force between the tyres and the road is 200 N and the air resistance (drag) is 80 N.

(i) Calculate the acceleration of the car.

\[
\text{acceleration} = \text{......................... m s}^{-2}
\]
(ii) Explain why we cannot use the equation \( v = u + at \) to predict the velocity of the car at a later time even when the forward force is constant.

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[Total 3 marks]