1 A skydiver jumps from a stationary hot-air balloon several kilometres above the ground.

(a) In terms of acceleration and forces, explain the motion of the skydiver

immediately after jumping ....

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at a time **before** terminal velocity is reached ....

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at terminal velocity. ....

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.... **[6]**

(b) In the final stage of the fall, the skydiver is falling through air at a constant speed. The skydiver's kinetic energy does not change even though there is a decrease in the gravitational potential energy. State what happens to this loss of gravitational potential energy.

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.... **[1]**

(c) Fig. 3.1 shows a sketch graph of the variation of the velocity *v* of the skydiver with time *t*.

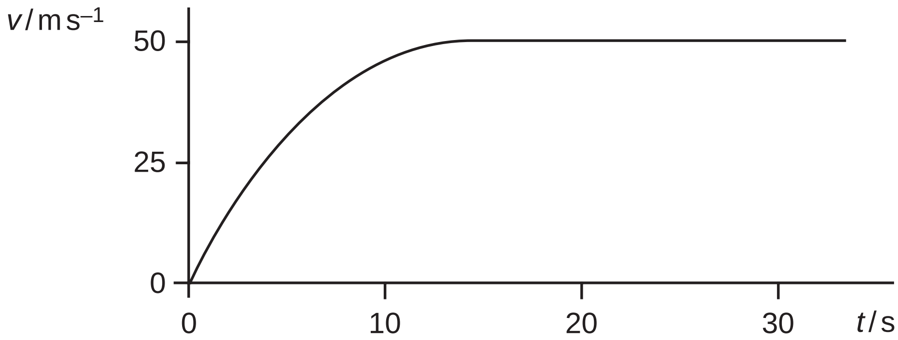

Fig. 3.1

Suggest the changes to the graph of Fig. 3.1, if any, for a more massive (heavier) skydiver of the same shape.

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.... **[2]**

[Total: 9]

2 **(a)** Fig. 5.1 shows a wooden block motionless on an inclined ramp.

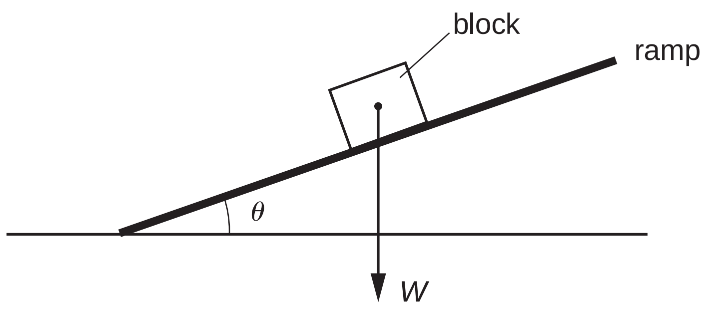

Fig. 5.1

The angle between the ramp and the horizontal is θ.

(i) The weight W of the block is already shown on Fig. 5.1. Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block. **[2]**

(ii) Write an equation to show how F is related to W and θ.

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.... **[1]**

(b) Fig. 5.2 shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at **A**.

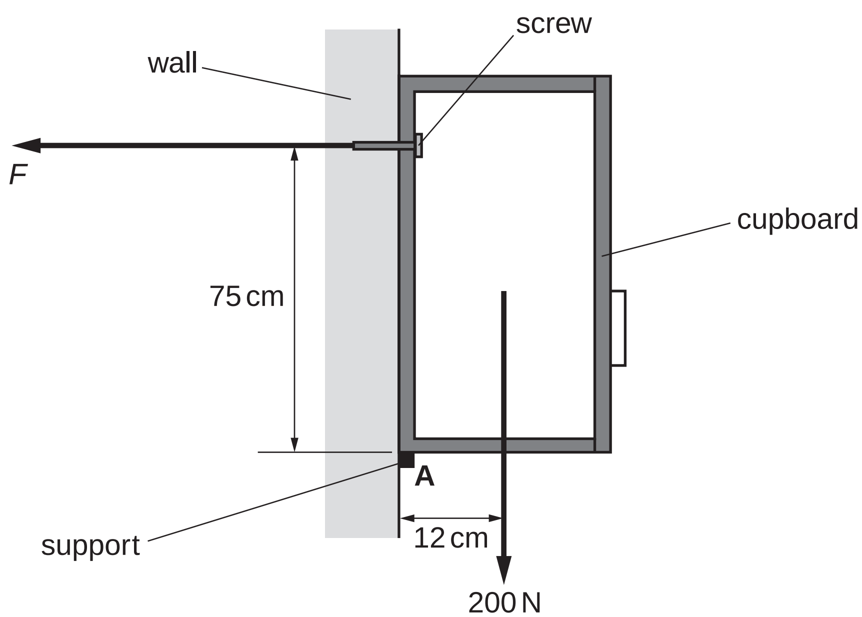

Fig. 5.2

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 Fig. 5.2. Take moments about **A**. Determine the value of F.

F = ... 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.

pressure = ... Pa **[2]**

(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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.... **[2]**

[Total: 11]

3 In February 1999 NASA launched its Stardust spacecraft on a mission to collect dust particles from the comet Tempel 1. After a journey of 5.0×10^{12} m that took 6.9 years, Stardust returned to Earth with samples of the dust particles embedded in a special low-density gel. When a dust particle hits the gel, it buries itself in the gel creating a cone-shaped track as shown in Fig. 6.1. The length of the track is typically 200 times the diameter of the dust particle.

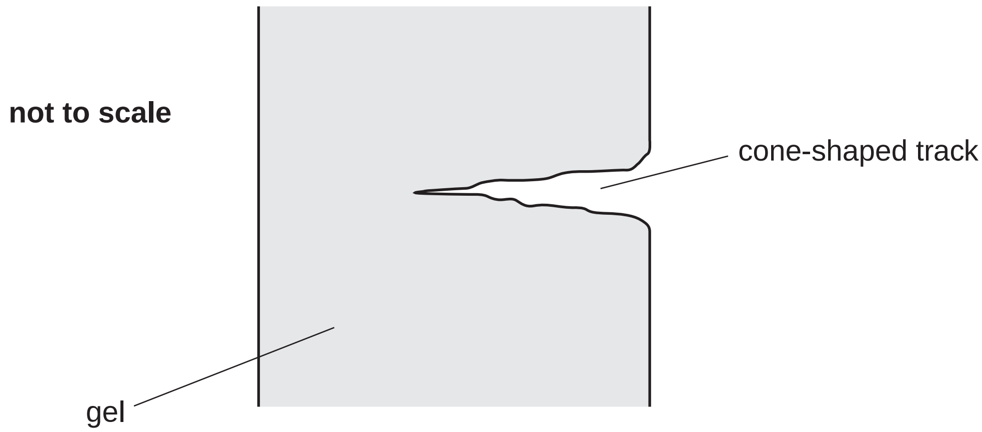

Fig. 6.1

(a) Calculate the average speed in $m\,s^{-1}$ of Stardust during its voyage.

speed = ... $m\,s^{-1}$ **[2]**

(b) Calculate the average stopping force produced by the gel for a dust particle of diameter 0.70 mm and mass 4.0×10^{-6} kg travelling at a velocity of $6.1 \times 10^{3}\,m\,s^{-1}$ relative to Stardust.

force = ...N **[3]**

[Total: 5]

4 **(a)** State how the magnitude of the drag force on an object is affected by its speed.

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.... **[1]**

(b) Describe the experiments Galileo carried out which overturned Aristotle's ideas of motion.

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.... **[3]**

(c) A skydiver is falling towards the ground at a terminal velocity of $50\,m\,s^{-1}$.

(i) State the **two** main forces acting on the skydiver and how they are related at terminal velocity.

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.... **[1]**

(ii) The skydiver opens her parachute. After some time, the skydiver reaches a lower terminal velocity of $4.0\,m\,s^{-1}$. Describe and explain how the magnitude of the deceleration of the skydiver changes as her velocity reduces from $50\,m\,s^{-1}$ to $4.0\,m\,s^{-1}$.

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.... **[4]**

[Total: 9]

5 **(a)** Fig. 7.1 shows several forces acting on an object that is free to move.

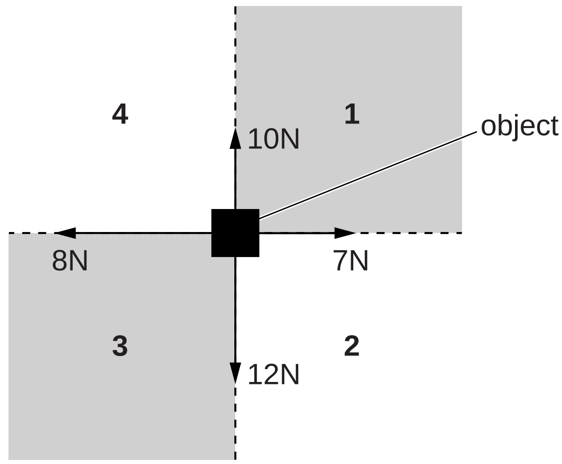

Fig. 7.1

Using simple calculations, deduce whether the object will move into region **1**, **2**, **3** or **4**. Briefly explain your reasoning.

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.... **[2]**

(b) State the *principle of moments*.

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.... **[1]**

(c) Fig. 7.2 shows the forces acting on a suitcase with wheels as it is held stationary.

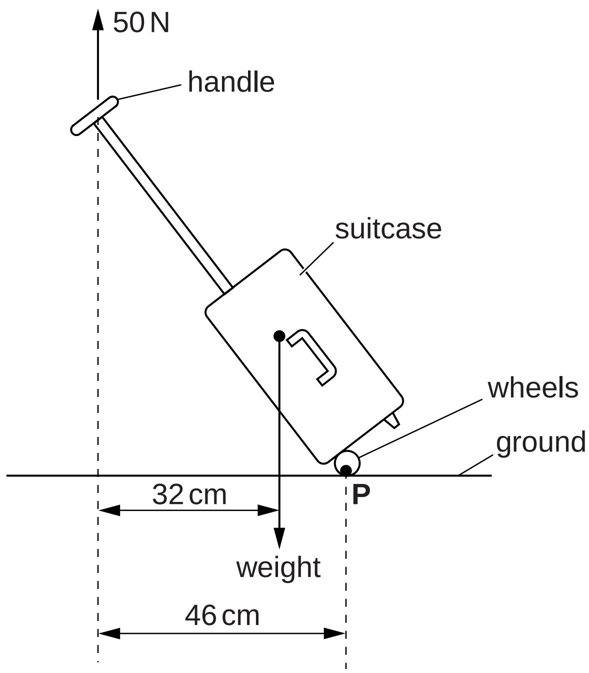

Fig. 7.2

A vertical force of 50 N is applied to the top of the handle in order to keep the suitcase stationary in the position shown in Fig. 7.2. The line of action of this force acts at a perpendicular distance of 46 cm from **P**, the point of contact with the ground. The line of action of the weight of the suitcase acts at a perpendicular distance of 32 cm from the top of the handle.

By taking moments about **P**, calculate the mass *m* of the suitcase.

m = ... kg **[3]**

[Total: 6]

6 Thinking and braking distances are important quantities when considering road safety.

(a) The driver of a car travelling at constant speed sees a hazard ahead at time $t = 0$. The reaction time of the driver is 0.5 s. On Fig. 3.1, sketch a graph of distance travelled by the car against time t during this interval of 0.5 s.

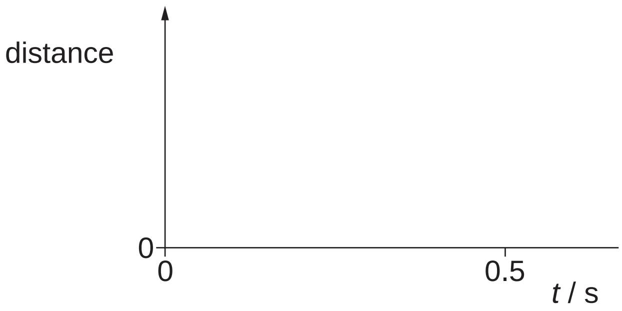

Fig. 3.1 **[1]**

(b) Explain the shape of your graph in Fig. 3.1.

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.... **[1]**

(c) Define *braking distance*.

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.... **[1]**

(d) Apart from the conditions of the tyres, brakes, road surface and weather, state two other factors that affect the **braking distance** of a car. For each factor, discuss how it affects the braking distance.

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.... **[4]**

(e) Describe and explain how seat belts reduce the forces on a driver during the impact in an accident.

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.... **[3]**

[Total: 10]