1 **(a)** Define the following terms:

(i) *couple*

....

.... **[1]**

(ii) *torque of a couple*.

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

....

.... **[1]**

(b) Fig. 4.1 shows a satellite in space moving from left to right.

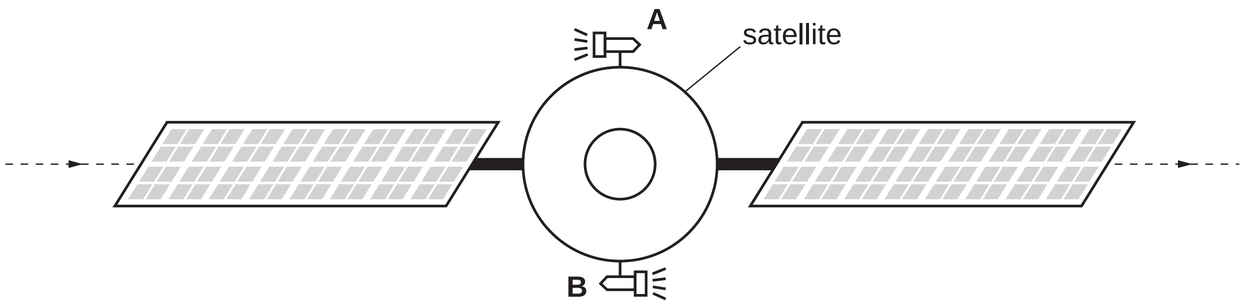

Fig. 4.1

The satellite has two small rockets **A** and **B** mounted at opposite ends of a diameter. When fired, each rocket motor provides the **same** constant force, but in **opposite** directions.

Describe the change in the motion of the satellite when

(i) both rocket motors are fired

....

....

.... **[2]**

(ii) only rocket motor **A** is fired.

....

....

.... **[2]**

[Total: 6]

2 **(a)** Define *density*.

....

.... **[1]**

(b) Fig. 2.1 shows the variation of density of the Earth with **depth** from the surface.

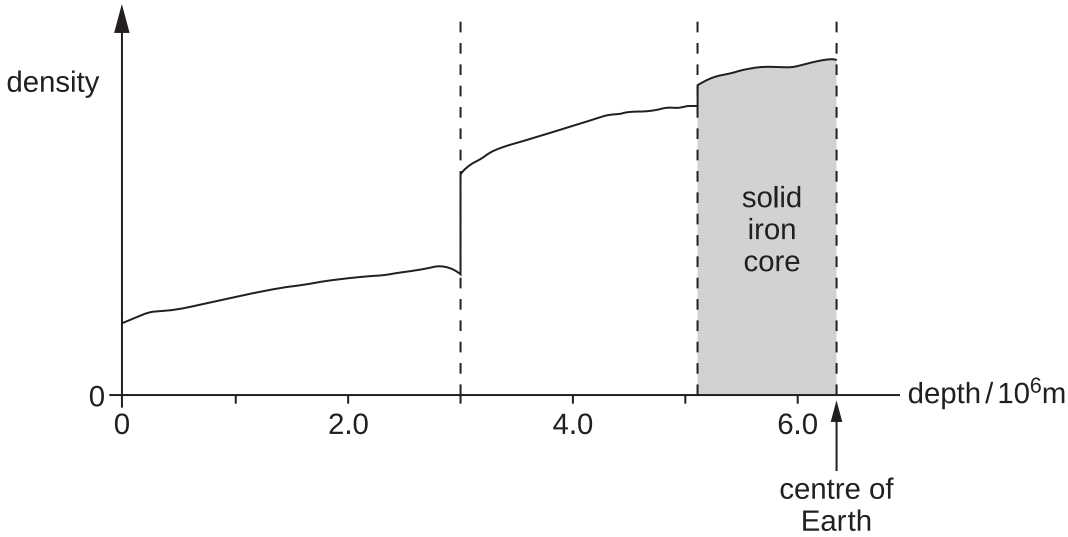

Fig. 2.1

(i) Suggest how Fig. 2.1 shows that the Earth consists of a number of distinct layers.

....

.... **[1]**

(ii) Geophysicists believe that the central core of the Earth is solid iron. This central core is surrounded by a layer of molten metal. The central core starts at a **depth** of 5.1×10^6 m. The solid iron core accounts for 18% of the mass of the Earth. The mass of the Earth is 6.0×10^{24} kg and its radius is 6.4×10^6 m. Calculate the mean density of the central core of the Earth.

volume of a sphere = $\frac{4}{3}\pi r^3$

density = ... $kg\,m^{-3}$ **[3]**

[Total: 5]

3 **(a)** State two factors that affect the magnitude of the drag force acting on an object falling through air.

1. ....

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

(b) Fig. 4.1 shows a skydiver of total mass 75 kg falling vertically towards the ground.

Fig. 4.1

The air resistance, or drag force, D in newtons (N) acting on the skydiver falling through the air is given by the equation

$$D = 0.3v^2$$

where v is the speed in $m\,s^{-1}$ of the skydiver.

(i) On Fig. 4.1, draw arrows to represent the weight (labelled W) and drag force (labelled D). **[1]**

(ii) Calculate the weight of the skydiver.

weight = ... N **[1]**

(iii) At a particular instant, the speed of the skydiver is 20 $m\,s^{-1}$. Calculate the instantaneous acceleration of the skydiver.

acceleration = ... $m\,s^{-2}$ **[3]**

(iv) State the relationship between the forces *W* and *D* when the skydiver reaches terminal velocity.

....

.... **[1]**

(v) Determine the terminal velocity of the skydiver.

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

[Total: 10]

4 **(a)** Define the *newton*.

....

.... **[1]**

(b) Fig. 3.1 shows a spaceship on the surface of the Earth.

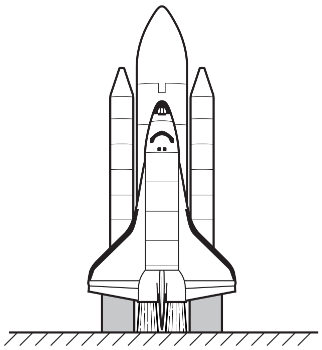

Fig. 3.1

The mass of the spaceship is 1.9×10^6 kg. During lift off, the spaceship rockets produce a vertical upward force of 3.1×10^7 N.

(i) Calculate the weight of the spaceship.

weight = ... N **[1]**

(ii) Calculate the initial vertical acceleration as the spaceship lifts off.

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

(iii) The vertical upward force on the spaceship stays constant. Explain why the acceleration of the spaceship increases after lift off.

....

....

....

.... **[1]**

[Total: 5]

5 **(a)** Define *braking distance* of a car.

....

....

.... **[1]**

(b) Other than the speed of the car, state two factors that affect the braking distance of a car. Describe how the braking distance is affected by each factor.

1. ....

....

....

....

2. ....

....

....

.... **[4]**

(c) Describe and explain how seat belts in cars reduce impact forces on the driver in an accident.

....

....

....

....

....

....

.... **[3]**

(d) Fig. 5.1 shows the variation of braking distance with speed *v* of a car.

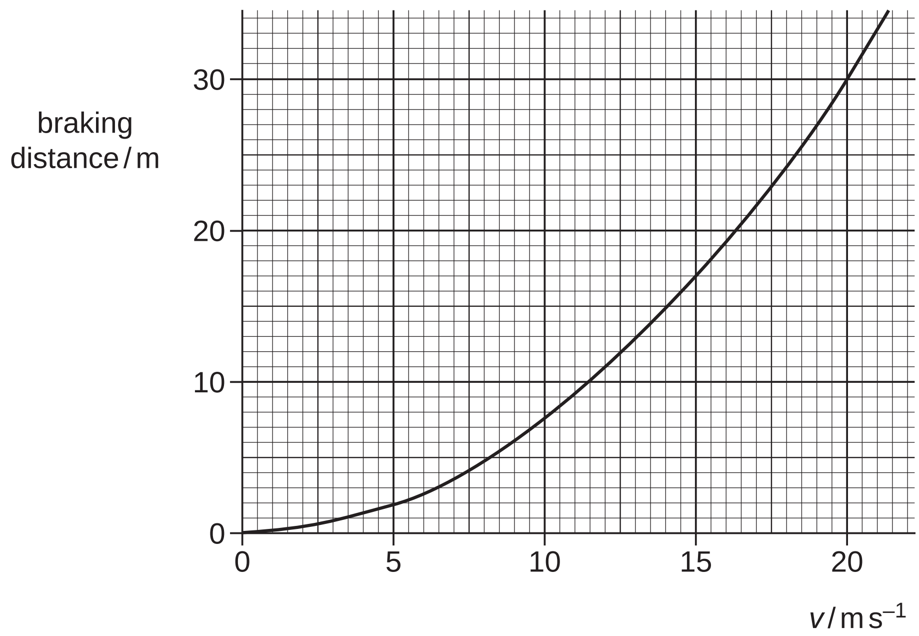

Fig. 5.1

(i) The car is travelling on a level straight road at a speed of 20 m s^{-1}. The reaction time of the driver is 0.50 s.

1 Calculate the thinking distance.

thinking distance = ... m

2 Hence, determine the stopping distance of the car.

stopping distance = ... m

[3]

(ii) In Fig. 5.1, the braking distance is directly proportional to the square of the speed. Determine the braking distance of the car when travelling at a speed of $32\,\text{m}\,\text{s}^{-1}$.

braking distance = ... m **[2]**

[Total: 13]

6 **(a)** Fig. 6.1 shows two equal but opposite forces acting on an object.

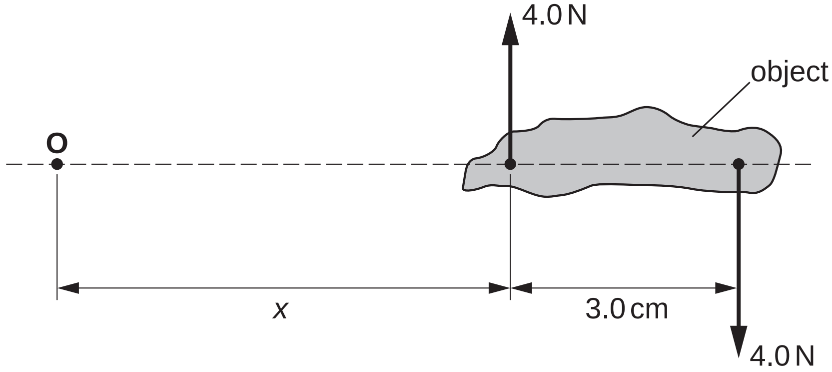

Fig. 6.1

The point **O** is at a distance *x* from the nearer of the two forces.

(i) The separation between the two parallel forces is 3.0 cm. Determine the torque of the couple exerted on the object.

torque = ... N m **[2]**

(ii) Calculate the total moment of the forces about the point **O** and state the significance of this value.

....

.... **[3]**

(b) State two conditions necessary for an object to be in equilibrium.

....

....

.... **[2]**

(c) A concrete paving slab has mass 45 kg and dimensions 0.600 m × 0.600 m × 0.050 m.

(i) Calculate the density of the concrete.

density = ... $kg\,m^{-3}$ **[2]**

(ii) Fig. 6.2 shows the concrete paving slab in equilibrium.

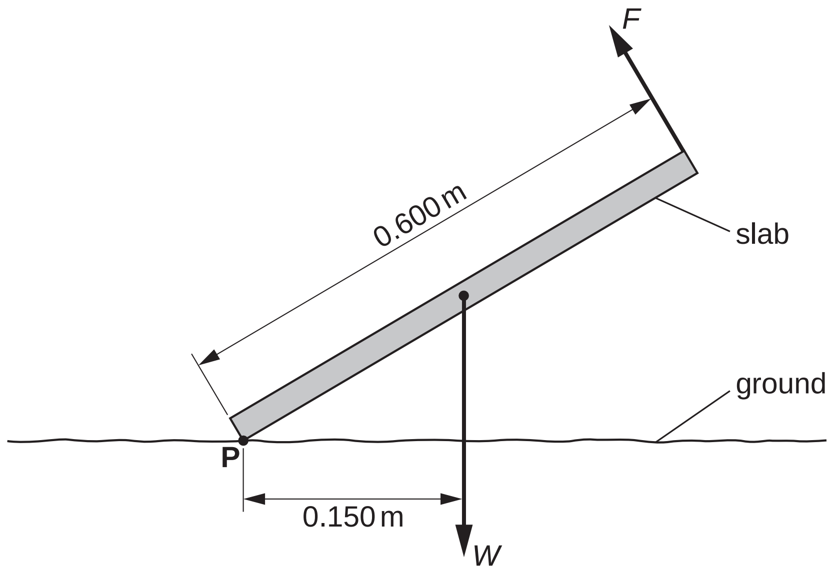

Fig. 6.2

Two forces acting on the slab are shown. The weight of the slab is *W*. The force *F* is applied at right angles to the end of the slab. By taking moments about **P**, determine the size of the force *F*.

F = ... N **[3]**

[Total: 12]