Answer **all** the questions.

1 **(a)** Define a *vector quantity*.

....

.... **[1]**

(b) Circle all the vector quantities in the list below.

acceleration speed time displacement weight **[1]**

(c) Fig. 1.1 shows graphs of velocity v against time t for two cars **A** and **B** travelling along a straight level road in the same direction.

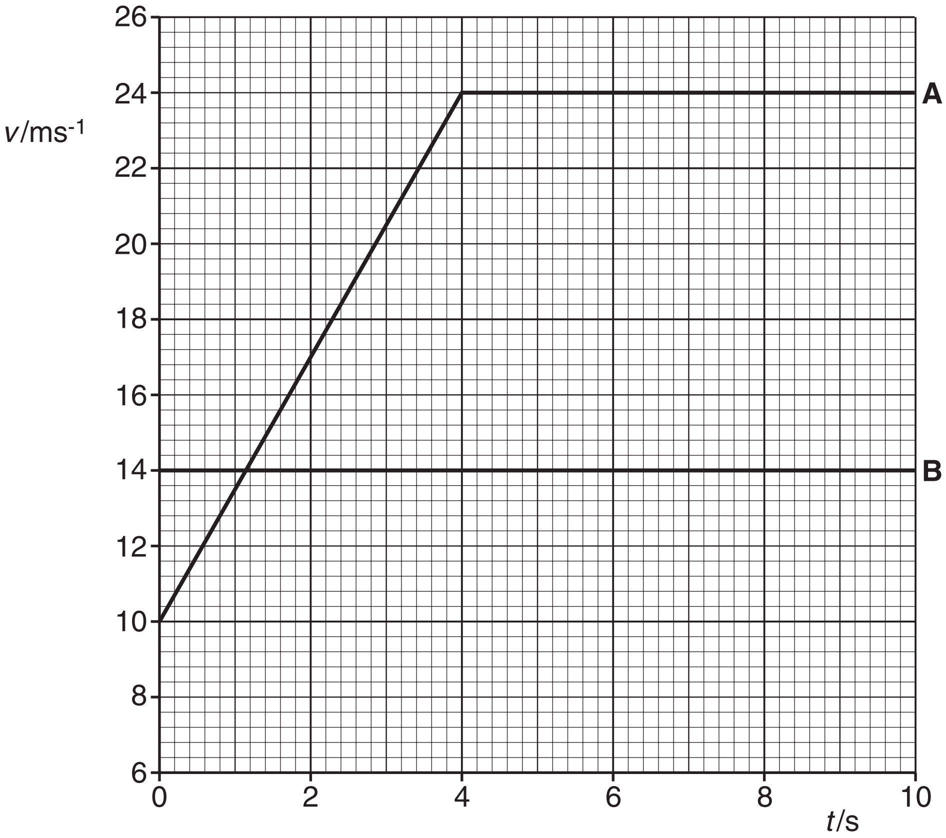


Fig. 1.1

At time $t = 0$, both cars are side-by-side.

(i) Describe the motion of car **A** from $t = 0$ to $t = 10$ s.

....

....

.... **[2]**

(ii) Calculate the distance travelled by car **A** in the first 4.0 s.

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

(iii) Use Fig. 1.1 to find

1 the time at which both cars have the same velocity

time = ... s **[1]**

2 the time *t* at which car **A** overtakes car **B**.

t = ... s **[2]**

[Total: 9]

Turn over

2 Fig. 2.1 shows the path of water from a hose pipe.

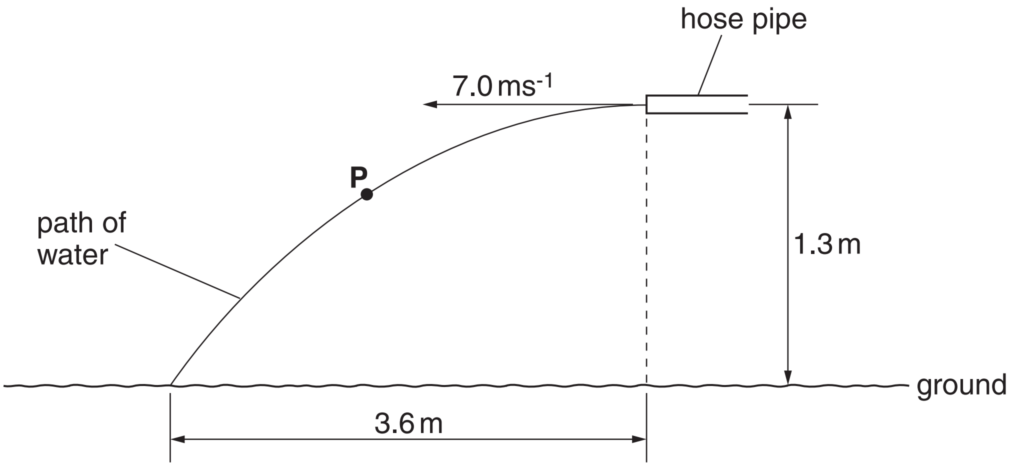


Fig. 2.1

The end of the horizontal hose pipe is at a height of 1.3 m from the ground. The initial horizontal velocity of the water is 7.0 m s^{-1}. The horizontal distance from the end of the hose pipe to the point where the water hits the ground is 3.6 m. You may assume that air resistance has negligible effect on the motion of the water jet.

(a) On Fig. 2.1, draw an arrow to show the direction of the acceleration of the water at point **P**. (Mark this arrow **A**). **[1]**

(b) Describe the energy conversion that takes place as the water travels from the end of the hose pipe to the ground.

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

....

....

....

.... **[2]**

(c) Explain why the horizontal component of the velocity remains constant at 7.0 m s^{-1}.

....

.... **[1]**

(d) Show that the water takes about 0.5 s to travel from the end of the pipe to the ground.

[1]

(e) Show that the speed of the water when it hits the ground is $8.6\,m\,s^{-1}$.

[3]

[Total: 8]

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

....

.... **[1]**

(b) State why the equation '$F = ma$' cannot be applied to particles travelling at speeds very close to the speed of light.

....

.... **[1]**

(c) Fig. 3.1 shows the horizontal forces acting on a car of mass 900 kg when it is travelling at a particular velocity on a level-road.

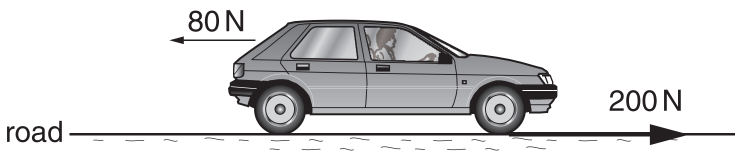


Fig. 3.1

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.

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

....

.... **[1]**

(d) Fig. 3.2 shows a person being lifted vertically upwards by a rope.

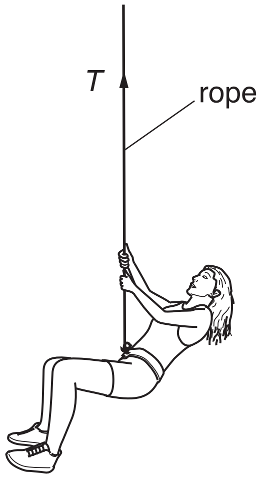


Fig. 3.2

The mass of the person is 72 kg. The upward vertical acceleration of the person is 1.4 m s^{-2}.
Calculate the tension *T* in the rope.

T = ... N **[3]**

[Total: 8]

4 **(a)** Define *torque of a couple*.

....

.... **[1]**

(b) Explain why *moment of a force* and *torque of a couple* have the same unit N m.

....

.... **[1]**

(c) Fig. 4.1 shows an irregular shaped metal plate of constant thickness that can swing freely about point **P**.

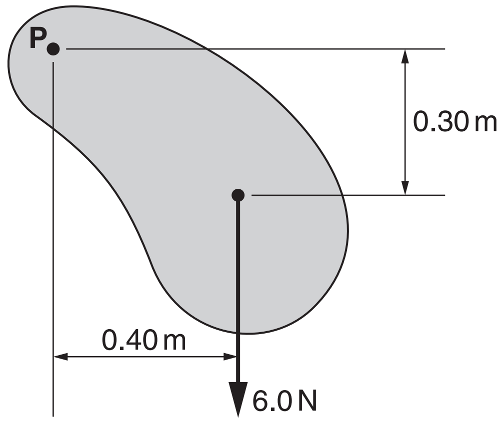


Fig. 4.1

(i) The weight of the plate is 6.0 N. With the plate in the position as shown in Fig. 4.1, calculate the clockwise moment of the weight of the plate about an axis through point **P**.

moment = ... N m **[1]**

(ii) Explain why the moment of the weight reduces to zero when the plate reaches the bottom of the swing.

....

.... **[1]**

(d) Describe an experiment to determine the centre of gravity of the metal plate shown in Fig. 4.1.

....

....

....

....

.... **[3]**

(e) Fig. 4.2 shows a section of the human forearm in equilibrium.

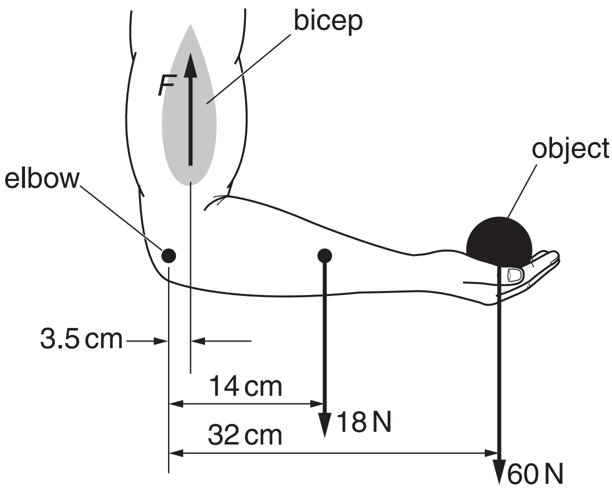


Fig. 4.2

The weight of the object in the hand is 60 N. The centre of gravity of this object is 32 cm from the elbow. The bicep provides an upward force of magnitude *F*. The distance between the line of action of this force and the elbow is 3.5 cm. The weight of the forearm is 18 N. The distance between the centre of gravity of the forearm and the elbow is 14 cm.

By taking moments about the elbow, determine the magnitude of the force *F* provided by the bicep.

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

[Total: 10]

5 **(a)** Fig. 5.1 shows a 20 N force acting at an angle of 38° to the horizontal.

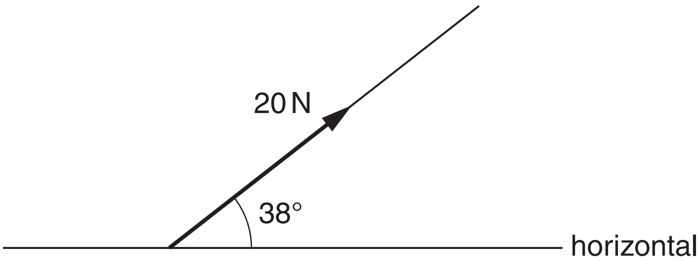


Fig. 5.1

Determine the horizontal and vertical components of this force.

horizontal component = ... N **[1]**

vertical component = ... N **[1]**

(b) Fig. 5.2 shows a metal block held in equilibrium by two wires.

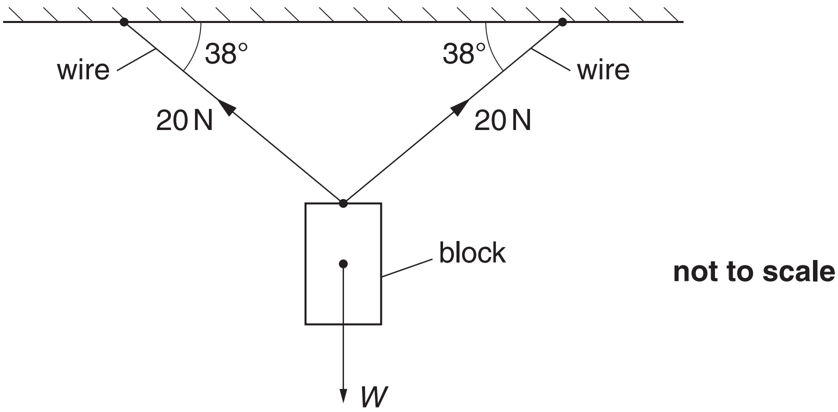


Fig. 5.2

The tension in each wire is 20 N.

(i) Show that the weight W of the metal block is about 25 N.

[2]

(ii) The metal block has a volume of $2.9 \times 10^{-4}\,m^3$. Calculate the density of the metal.

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

[Total: 7]

6 **(a)** Define *stopping distance* of a car.

....

.... **[1]**

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

....

....

....

....

.... **[4]**

(c) 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.

....

....

....

....

....

....

.... **[4]**

[Total: 9]

7 **(a)** In what form is energy stored when a metal wire is extended by a force?

.... **[1]**

(b) A metal wire of length 1.2 m is clamped vertically. A weight is hung from the lower end of the wire. The extension of the wire is 0.35 mm. The cross-sectional area of the wire is $1.4 \times 10^{-7}\,m^2$ and the Young modulus of the metal is 1.9×10^{11} Pa.

Calculate

(i) the strain of the wire

strain = ... **[1]**

(ii) the tension in the wire.

tension = ... N **[2]**

Question 7 is continued over the page.

(c) There is great excitement at the moment about structures known as carbon nanotubes (CNTs). CNTs are cylindrical tubes of carbon atoms. These cylindrical tubes have diameter of a few nanometres and can be several millimetres in length. Carbon nanotubes are one of the strongest and stiffest materials known. Recently a carbon nanotube was tested to have an ultimate tensile strength of about 60 GPa. In comparison, high-carbon steel has an ultimate tensile strength of about 1.2 GPa. Under excessive tensile stress, the carbon nanotubes undergo plastic deformation. This deformation begins at a strain of about 5%. Carbon nanotubes have a low density for a solid. Carbon nanotubes have recently been used in high-quality racing bicycles.

(i) **1** The diameter of CNTs is a *few nanometres*. What is one nanometre in metres?

.... **[1]**

2 Explain what is meant by *plastic deformation*.

....

....

.... **[1]**

(ii) How many times stronger are CNTs than high-carbon steel?

....

.... **[1]**

(iii) State two advantages of making a bicycle frame using CNT technology rather than high-carbon steel.

....

....

.... **[2]**

[Total: 9]

END OF QUESTION PAPER

Answer **all** questions.

1 (a) One of the assumptions of the kinetic theory of gases is that gas molecules move with random motion. State **two** other assumptions of the kinetic theory of gases.

....

....

....

....

....

(2 marks)

(b) Explain why the average velocity of the gas molecules in a container is zero.

....

....

....

....

....

(2 marks)

(c) The pressure a gas exerts on the walls of a container depends on the *mean square speed* of the molecules. Explain what is meant by mean square speed.

....

....

....

....

(2 marks)

(d) Explain why the mean square speeds of the gas molecules of two different gases at the same temperature are **not** the same.

....

....

....

....

....

(2 marks)

8

Turn over for the next question

2 (a) State the principle of moments for a body in equilibrium.

....

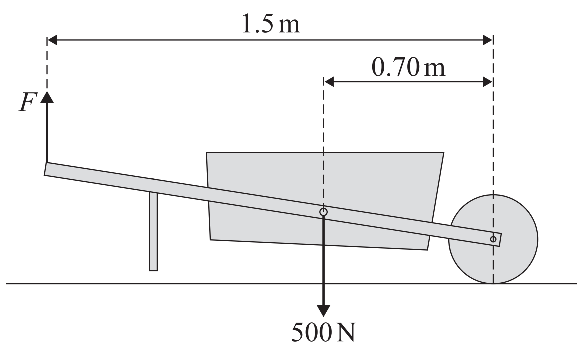
....

....

(2 marks)

(b) **Figure 1** shows a vertical force, *F*, being applied to raise a wheelbarrow which has a total weight of 500 N.

Figure 1



(i) On **Figure 1** draw an arrow to represent the position and direction of the force, *R*, exerted by the ground on the wheel.

(ii) Calculate the minimum value of the vertical force, *F*, needed to raise the legs of the wheelbarrow off the ground.

....

....

....

(iii) Calculate the magnitude of *R* when the legs of the wheelbarrow have just left the ground.

....

....

....

(5 marks)

7

3 A steady stream of water strikes a wall horizontally without rebounding and, as a result, exerts a force on the vertical wall.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer to Question 3(a).

(a) With reference to Newton's Laws of motion,

(i) state and explain why the momentum of the water changes as it strikes the wall,

....

....

....

(ii) explain why the water exerts a constant force on the wall.

....

....

....

(5 marks)

(b) Water arrives at the wall at a rate of $18\,\text{kg}\,\text{s}^{-1}$. It strikes the wall horizontally, at a speed of $7.2\,\text{m}\,\text{s}^{-1}$ without rebounding. Calculate

(i) the change in momentum of the water in **one** second,

....

....

....

(ii) the force exerted by the water on the wall.

....

(3 marks)

(c) State and explain the effect on the magnitude of the force if the water rebounds after striking the wall.

....

....

....

(2 marks)

Turn over ▶ **10**

4 A dart is thrown horizontally at a speed of $8.0\,m\,s^{-1}$ towards the centre of a dartboard that is 2.0 m away. At the same instant that the dart is released, the support holding the dartboard fails and the dartboard falls freely, vertically downwards. The dart hits the dartboard in the centre before they both reach the ground.

(a) State and explain the motion of the dart and the dartboard, while the dart is in flight.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

....

....

....

....

....

....

(4 marks)

(b) Calculate

(i) the time taken for the dart to hit the dartboard,

....

....

(ii) the vertical component of the dart's velocity just before it strikes the dartboard,

....

....

(iii) the magnitude and direction of the resultant velocity of the dart as it strikes the dartboard.

....

....

....

....

(5 marks)

9

5 An aircraft accelerates horizontally from rest and takes off when its speed is $82\,\mathrm{m\,s^{-1}}$. The mass of the aircraft is $5.6 \times 10^4\,\mathrm{kg}$ and its engines provide a constant thrust of $1.9 \times 10^5\,\mathrm{N}$.

(a) Calculate

(i) the initial acceleration of the aircraft,

....

....

(ii) the minimum length of runway required, assuming the acceleration is constant.

....

....

....

(3 marks)

(b) In practice, the acceleration is unlikely to be constant. State a reason for this and explain what effect this will have on the minimum length of runway required.

....

....

....

....

(2 marks)

(c) After taking off, the aircraft climbs at an angle of 22° to the ground. The thrust from the engines remains at $1.9 \times 10^5\,\mathrm{N}$. Calculate

(i) the horizontal component of the thrust,

....

....

(ii) the vertical component of the thrust.

....

....

(2 marks)

7

Turn over ▸

6 A car of mass 1200 kg is travelling at $12\,\mathrm{m\,s^{-1}}$. When the brakes are applied the car comes uniformly to rest in 6.0 s.

(a) Calculate the kinetic energy lost by the car.

....

....

(2 marks)

(b) Approximately 70% of the kinetic energy of the car is converted into thermal energy in the brakes of the car when coming to rest. The total mass of the brake components is 28 kg and their average specific heat capacity is $540\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

(i) Estimate the temperature rise of the brake components.

....

....

....

(ii) State and explain where some of the remaining energy is likely to have been dissipated.

....

....

....

....

(5 marks)

7

Quality of Written Communication *(2 marks)*

2

END OF QUESTIONS

Answer **all** the questions.

1 **(a)** Draw a line from each unit on the left-hand side to the correct equivalent unit on the right-hand side.

joule (J)	kg m s^{-2}
watt (W)	N m
newton (N)	J s^{-1}

[2]

(b) This question is about estimating the pressure exerted by a person wearing shoes standing on a floor, see Fig. 1.1.

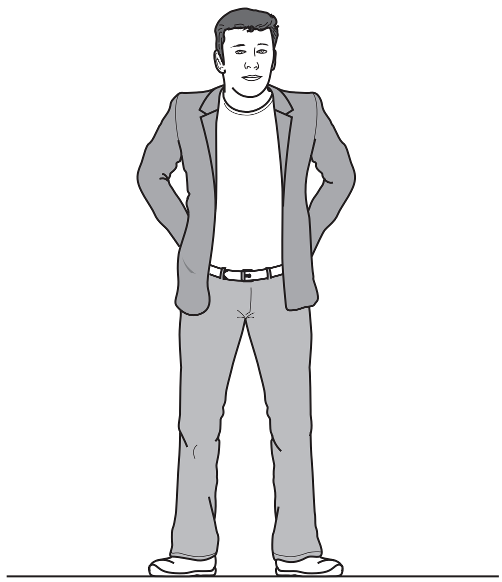


Fig. 1.1

(i) Estimate the weight in newtons of a person.

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

(ii) Estimate the total area of contact in square metres between the shoes of this person and the floor.

area = ... m^2 **[1]**

(iii) Hence estimate the pressure in pascals exerted by this person standing on the floor.

pressure = ... Pa **[1]**

[Total: 5]

2 Fig. 2.1 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.

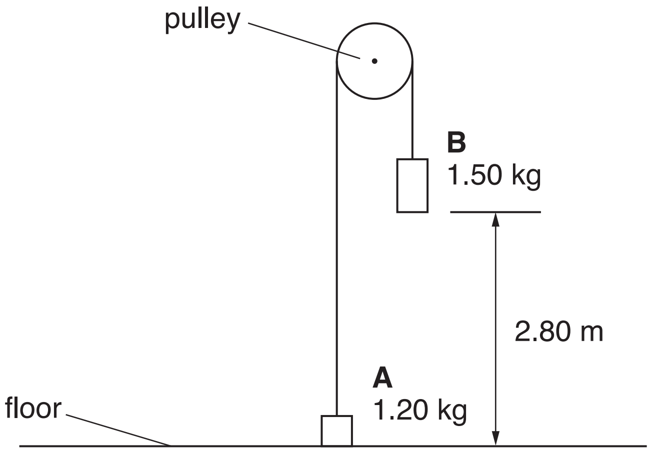


Fig. 2.1

The mass **A** is 1.20 kg and the mass **B** is 1.50 kg.

(a) Calculate the weight of mass **B**.

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

(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*.

....

.... **[1]**

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

time = ... s **[3]**

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

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

(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.

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

[Total: 9]

Turn over

3 A lift has a mass of 500 kg. It is designed to carry a maximum of 8 people of total mass 560 kg. The lift is supported by a steel cable of cross-sectional area $3.8 \times 10^{-4}\,m^2$. When the lift is at ground floor level the cable is at its maximum length of 140 m, as shown in Fig. 3.1. The mass per unit length of the cable is $3.0\,kg\,m^{-1}$.

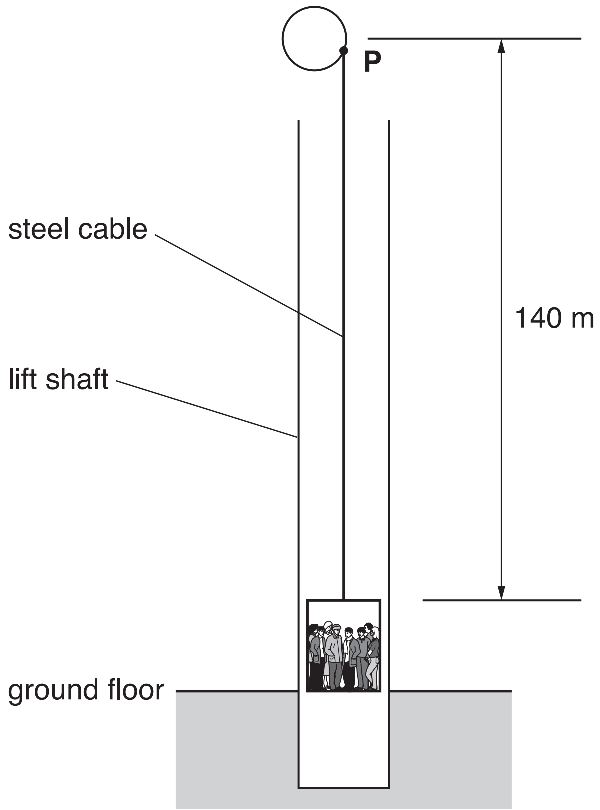


Fig. 3.1

(a) Show that the mass of the 140 m long steel cable is 420 kg.

[1]

(b) **(i)** The lift with its 8 passengers is stationary at the ground floor level. The initial upward acceleration of the lift and the cable is $1.8\,\mathrm{m\,s^{-2}}$. Show that the **maximum** tension in the cable at point **P** is $1.7 \times 10^4\,\mathrm{N}$.

[4]

(ii) Calculate the maximum stress in the cable.

stress = ... Pa **[2]**

[Total: 7]

4 **(a)** An electron in a particle accelerator experiences a constant force. According to one student, the acceleration of the electron should remain constant because the ratio of force to mass does not change. In reality, experiments show that the acceleration of the electron decreases as its velocity increases. Describe what can be deduced from such experiments about the nature of accelerated electrons.

....

....

....

.... **[2]**

(b) Fig. 4.1 shows the velocity vector for a particle moving at an angle of 31° to the horizontal.

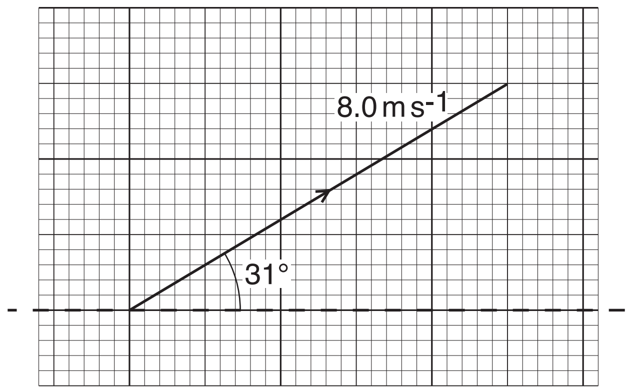


Fig. 4.1

(i) On Fig. 4.1, show the horizontal (*x*-direction) and vertical (*y*-direction) components of the velocity. **[2]**

(ii) Calculate the horizontal (*x*-direction) component of the velocity.

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

(c) Fig. 4.2 shows a ship **S** being pulled by two tug-boats.

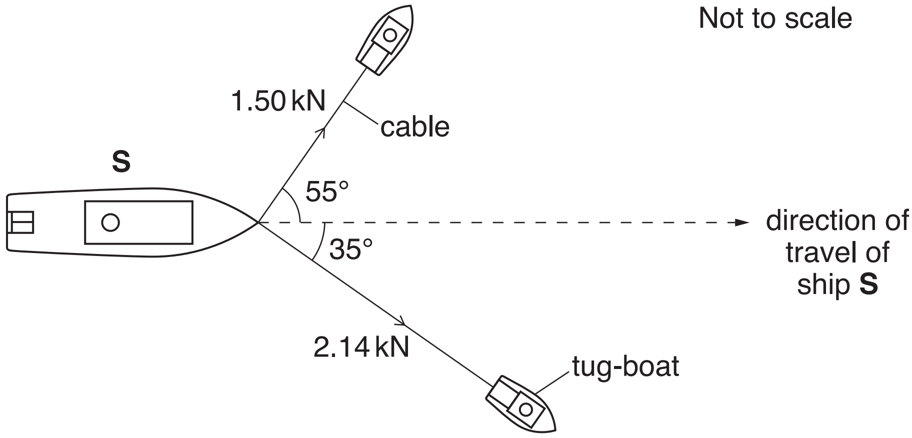


Fig. 4.2

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 Fig. 4.2.

(i) Draw a vector triangle and determine the resultant force provided by the two cables.

resultant force = ... kN **[3]**

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

....

....

.... **[2]**

[Total: 10]

5 **(a)** State the principle of conservation of energy.

....

.... **[1]**

(b) Describe one example where elastic potential energy is stored.

.... **[1]**

(c) Fig. 5.1 shows a simple pendulum with a metal ball attached to the end of a string.

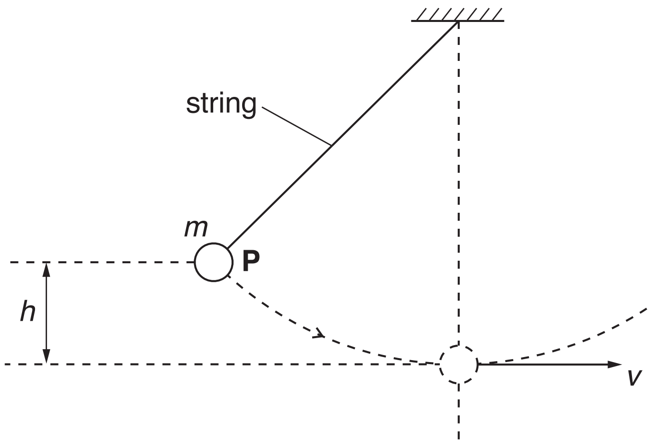


Fig. 5.1

When the ball is released from **P**, it describes a circular path. The ball has a maximum speed v at the bottom of its swing. The vertical distance between **P** and bottom of the swing is h. The mass of the ball is m.

(i) Write the equations for the change in gravitational potential energy, E_p, of the ball as it drops through the height h and for the kinetic energy, E_k, of the ball at the bottom of its swing when travelling at speed v.

E_p =

E_k = **[1]**

(ii) Use the principle of conservation of energy to derive an equation for the speed v. Assume that there are no energy losses due to air resistance.

[2]

(d) Some countries in the world have frequent thunderstorms. A group of scientists plan to use the energy from the falling rain to generate electricity. A typical thunderstorm deposits rain to a depth of 1.2×10^{-2} m over a surface area of 2.0×10^{7} m^{2} during a time of 900 s. The rain falls from an average height of 2.5×10^{3} m. The density of rainwater is 1.0×10^{3} kg m^{-3}. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

(i) Show that the total mass of water deposited in 900 s is 2.4×10^{8} kg.

[2]

(ii) Hence show that the average electrical power available from this thunderstorm is about 2 GW.

[3]

(iii) Suggest one problem with this scheme of energy production.

....

.... **[1]**

[Total: 11]

6 The force against length graph for a spring is shown in Fig. 6.1.

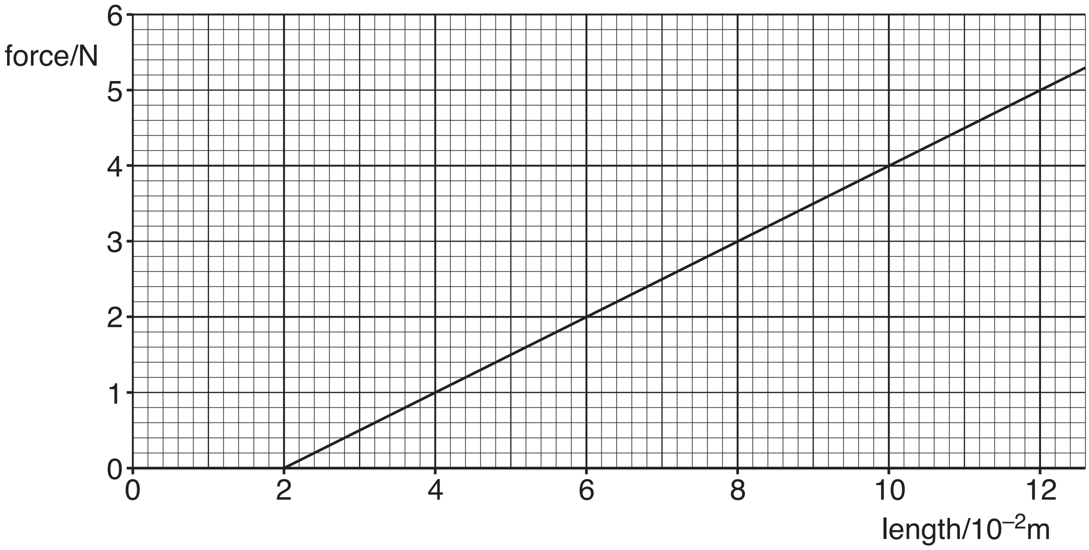


Fig. 6.1

(a) Explain why the graph does not pass through the origin.

....

.... **[1]**

(b) State what feature of the graph shows that the spring obeys Hooke's law.

....

.... **[1]**

(c) The gradient of the graph is equal to the force constant *k* of the spring. Determine the force constant of the spring.

force constant = ... $N\,m^{-1}$ **[2]**

(d) Calculate the work done on the spring when its length is increased from 2.0×10^{-2} m to 8.0×10^{-2} m.

work done = ... J **[2]**

(e) One end of the spring is fixed and a mass is hung vertically from the other end. The mass is pulled down and then released. The mass oscillates up and down. Fig. 6.2 shows the displacement *s* against time *t* graph for the mass.

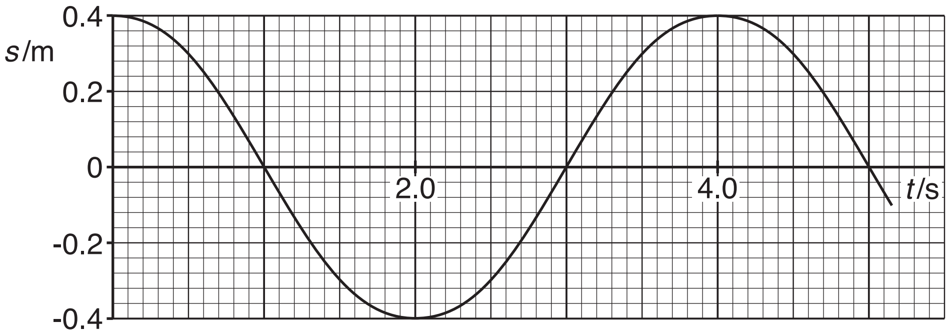


Fig. 6.2

Explain how you can use Fig. 6.2 to determine the **maximum** speed of the mass. You are not expected to do the calculations.

....

....

....

.... **[2]**

[Total: 8]

7 **(a)** Fig. 7.1 shows a length of tape under tension.

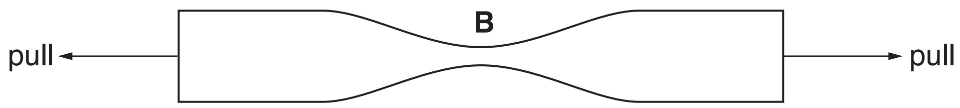


Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

....

.... **[1]**

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

....

....

.... **[1]**

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

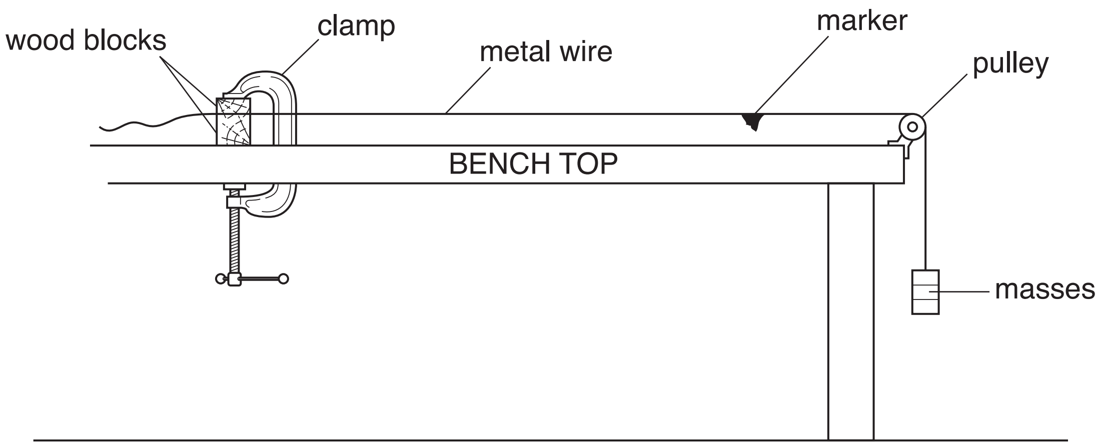


Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

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

The **equipment** used to take the measurements:

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

How you would **determine** Young modulus from your measurements:

[8]

[Total: 10]

END OF QUESTION PAPER

Answer **all** questions in the spaces provided.

1 (a) (i) State **two** conditions necessary for an object to be in equilibrium.

....

....

....

....

1 (a) (ii) For each condition state the consequence if the condition is not met.

....

....

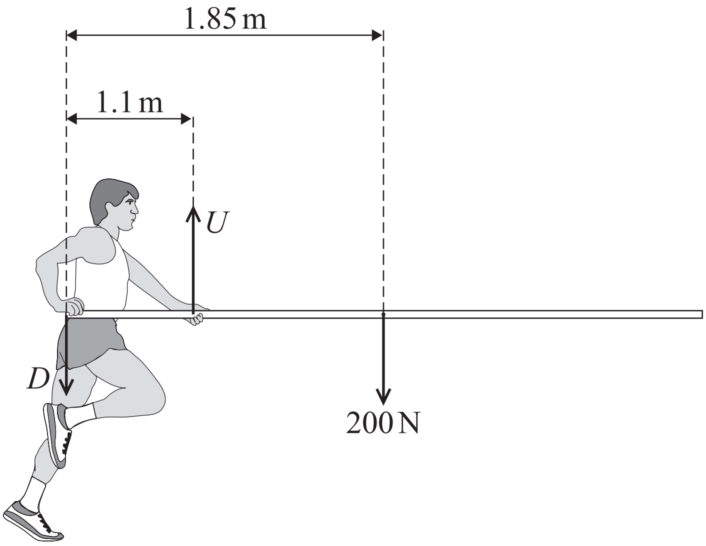
....

....

(4 marks)

Figure 1 shows a pole vaulter holding a uniform pole horizontally. He keeps the pole in equilibrium by exerting an upward force, *U*, with his leading hand, and a downward force, *D*, with his trailing hand.

Figure 1



weight of pole = 200 N
length of pole = 3.7 m

1 (b) Calculate for the situation shown in **Figure 1**,

1 (b) (i) the force, *U*,

....

....

1 (b) (ii) the force, *D*.

....

....

....

(3 marks)

1 (c) Explain the effect on the magnitudes of *U* and *D* if the vaulter moves his leading hand closer to the centre of gravity of the pole and the pole is still in equilibrium.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

....

....

....

....

....

....

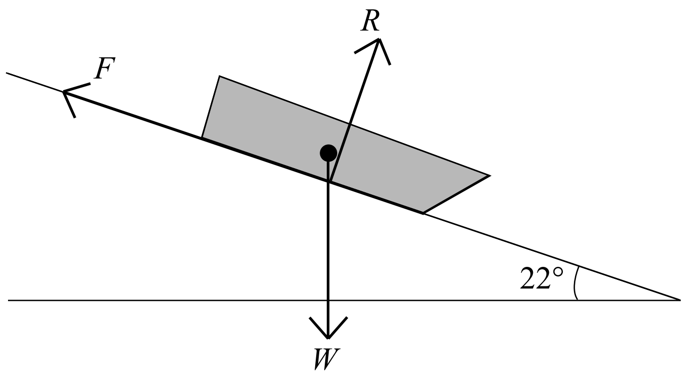
(3 marks)

10

Turn over for the next question

2 **Figure 2** shows a sledge moving down a slope at constant velocity.
The angle of the slope is 22°.

Figure 2



The three forces acting on the sledge are weight, *W*, friction, *F*, and the normal reaction force, *R*, of the ground on the sledge.

2 (a) With reference to an appropriate law of motion, explain why the sledge is moving at constant velocity.

....

....

....

....

....

....

(2 marks)

2 (b) The mass of the sledge is 4.5 kg. Calculate the component of *W*,

2 (b) (i) parallel to the slope,

....

....

....

2 (b) (ii) perpendicular to the slope,

....

....

....

(2 marks)

2 (c) State the values of *F* and *R*.

F ....

R ....

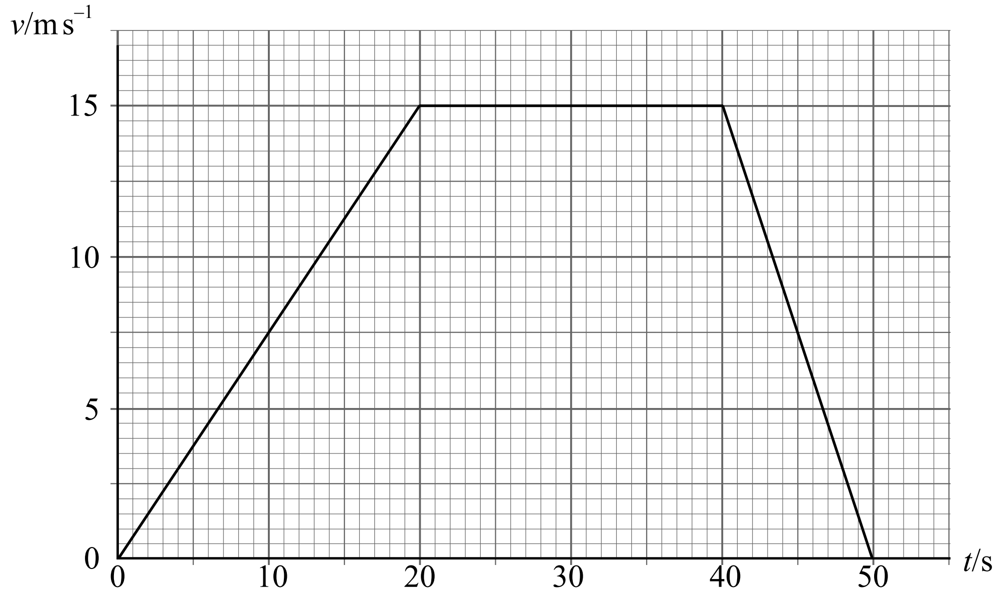
(2 marks)

6

Turn over for the next question

Turn over ▸

3 The graph shows how the velocity, v, of a car varies with time, t.



3 (a) Describe the motion of the car for the 50 s period.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

....

....

....

....

....

....

(3 marks)

3 (b) The mass of the car is 1200 kg. Calculate for the first 20 s of motion,

3 (b) (i) the change in momentum of the car,

....

....

....

....

3 (b) (ii) the rate of change of momentum,

....

....

3 (b) (iii) the distance travelled.

....

....

(4 marks)

7

Turn over for the next question

4 A kettle, rated at 2.5 kW, is used to raise the temperature of 1.2 kg of water from 20°C to 100°C and then convert some of the water to steam.

specific heat capacity of water = $4200\,J\,kg^{-1}K^{-1}$
specific latent heat of vaporisation of water = $2.3 \times 10^{6}\,J\,kg^{-1}$

4 (a) Calculate

4 (a) (i) the time taken to raise the temperature of the water from 20° C to 100° C,

....

....

....

....

4 (a) (ii) the additional time taken for the kettle to convert 10% of the water to steam.

....

....

....

(4 marks)

4 (b) State **two** reasons why in practice, the actual time taken in part 4(a)(i) will be longer.

....

....

....

....

(2 marks)

6

5 (a) 6.7 mol of an ideal gas in a rigid container exerts a pressure of 110 kPa at a temperature of 25°C.

5 (a) (i) Calculate the volume of the container.

....

....

....

5 (a) (ii) Calculate the average kinetic energy of a molecule of the gas.

....

....

....

5 (a) (iii) Deduce the pressure exerted by the gas if the average kinetic energy of the gas molecules is doubled.

....

....

....

(5 marks)

5 (b) Two of the assumptions about the behaviour of the molecules of an ideal gas are that they move with *random motion* and make *elastic collisions* with the walls of the container.

State and explain what is meant by

5 (b) (i) random motion,

....

....

....

Question 5 continues on the next page

5 (b) (ii) elastic collisions.

....

....

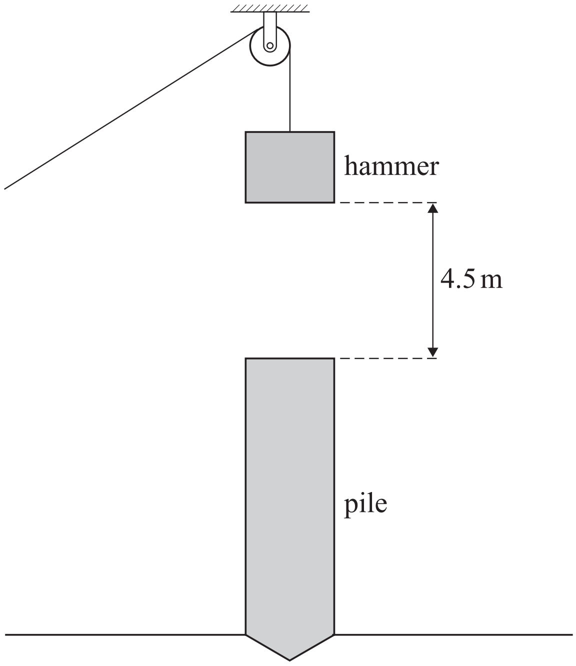
....

(3 marks)

8

6 A pile driver is used to drive cylindrical poles, called piles, into the ground so that they form the foundations of a building. **Figure 3** shows a possible arrangement for a pile driver. The hammer is held above the pile and then released so that it falls freely under gravity, until it strikes the top of the pile.

Figure 3



6 (a) State the main energy changes that take place as the hammer is falling.

....

....

....

(1 mark)

6 (b) The hammer has a mass of 250 kg and falls 4.5 m before striking the pile. After impact the hammer and pile move downwards together.
Calculate

6 (b) (i) the speed of the hammer just before impact,

....

....

6 (b) (ii) the momentum of the hammer just before the impact,

....

....

Question 6 continues on the next page

Turn over ▸

6 (b) (iii) the speed of the hammer and pile immediately after impact if the mass of the pile is 2000 kg.

....

....

....

(4 marks)

6 (c) After an impact the hammer and the pile move so that the pile sinks into the ground to a depth of 0.25 m.

Calcuate

6 (c) (i) the loss of kinetic energy of the hammer and pile,

....

....

....

6 (c) (ii) the average frictional force the ground exerts on the pile while bringing it to rest.

....

....

....

(4 marks)

6 (d) The process is repeated several times and each time the hammer is raised 4.5 m above the pile. Suggest why the extra depth of penetration is likely to decrease with each impact.

....

....

(2 marks)

11

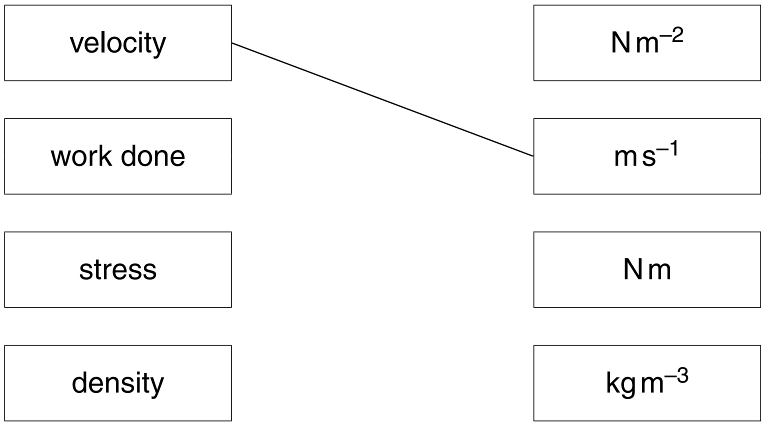
Quality of Written Communication *(2 marks)*

2

END OF QUESTIONS

Answer **all** the questions.

1 **(a)** Draw a straight line from each quantity on the left hand side to its correct unit on the right hand side; one has already been done for you.



[2]

(b) Fig. 1.1 shows a metal cube which rests on a table.

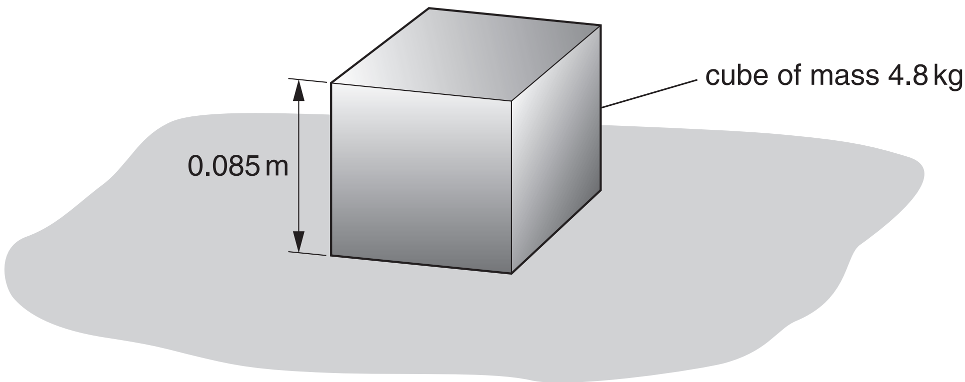


Fig. 1.1

The mass of the metal cube is 4.8 kg. Each side of the cube has length 0.085 m. The cube exerts pressure on the table.

(i) Complete the sentence below:

The force acting on the table is due to the .... of the metal cube. **[1]**

(ii) Calculate the pressure exerted on the table by the metal cube.

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

(iii) The metal cube shown is replaced by a second cube made of the same material but with each side of double the length of the original cube.

Complete the sentences below for the second cube when compared with the original cube.

The mass of the second cube is …………………… times greater than the original cube.

The cross-sectional area of the base is …………………… times greater than the original cube.

Hence, the pressure exerted by this cube is …………………… times greater than the original cube.

[3]

[Total: 8]

Turn over

2 A driver travelling in a car on a straight and level road sees an obstacle in the road ahead and applies the brakes until the car stops. The initial speed of the car is 20 m s^{-1}. The reaction time of the driver is 0.50 s.

Fig. 2.1 shows the velocity against time graph for the car.

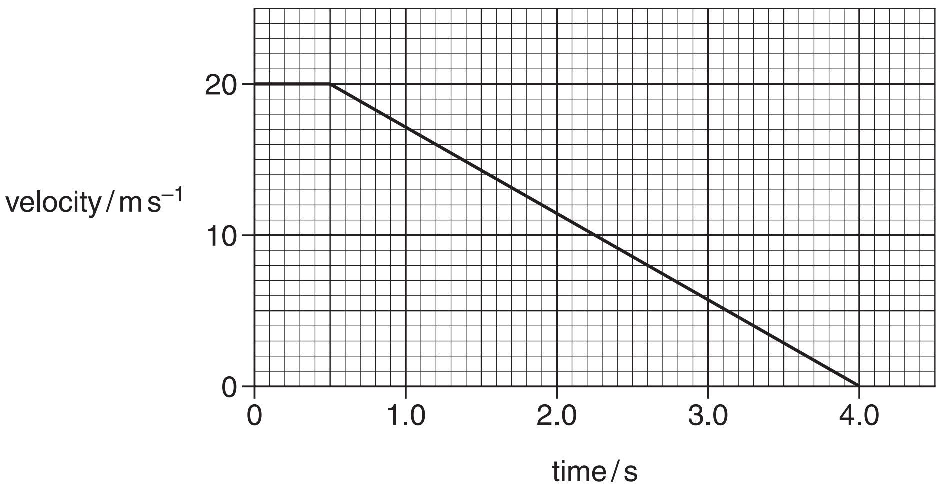


Fig. 2.1

(a) Define *thinking distance*.

....

.... **[1]**

(b) What does the area under a velocity against time graph represent?

.... **[1]**

(c) Use your answer to **(b)** and Fig. 2.1 to determine

(i) the thinking distance

thinking distance = ... m **[1]**

(ii) the braking distance.

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

(d) The total mass of the car is 910 kg. Use Fig. 2.1 to determine

(i) the magnitude of the deceleration of the car

deceleration = ... $m s^{-2}$ **[2]**

(ii) the braking force acting on the car as it decelerates.

force = ... N **[2]**

(e) Suppose the initial speed of the car is twice that shown in Fig. 2.1. The braking force remains the same. State and explain by what factor the **braking** distance would increase.

....

....

....

.... **[2]**

(f) One of the safety features in a car is the air bag for the driver. Briefly describe how the air bag is triggered and how it minimises the impact force on the driver.

....

....

....

....

....

....

....

....

....

....

....

.... **[4]**

[Total: 15]

3 **(a)** Define *work done* by a force.

....

.... **[1]**

(b) Fig. 3.1 shows a car travelling up a slope at a constant speed.

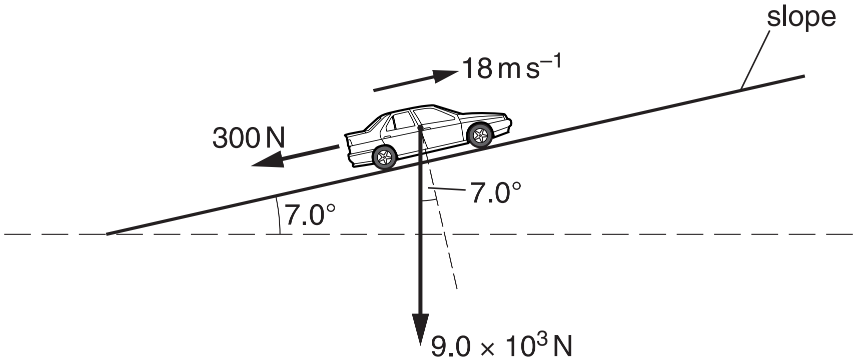


Fig. 3.1

The angle between the slope and the horizontal is 7.0°. The weight of the car is 9.0×10^3 N. The car travels up the slope at a constant speed of $18\,m\,s^{-1}$. A resistive force of 300 N acts on the car down the slope.

(i) What is the net force acting on the car? Explain your answer.

....

....

.... **[2]**

(ii) Calculate the component of the weight of the car acting down the slope.

component of weight = ... N **[2]**

(iii) Calculate the work done per second against the resistive force.

work done per second = ... $J s^{-1}$ **[1]**

(iv) Calculate the power developed by the car as it travels up the slope.

power = ... W **[3]**

[Total: 9]

4 **(a)** Write a word equation for *kinetic energy*.

kinetic energy =

[1]

(b) A bullet of mass 3.0×10^{-2} kg is fired at a sheet of plastic of thickness 0.015 m. The bullet enters the plastic with a speed of $200\,m\,s^{-1}$ and emerges from the other side with a speed of $50\,m\,s^{-1}$.

Calculate

(i) the loss of kinetic energy of the bullet as it passes through the plastic

loss of kinetic energy = ... J **[3]**

(ii) the average frictional force exerted by the plastic on the bullet.

frictional force = ... N **[2]**

[Total: 6]

5 Use your knowledge of physics to state if each statement is correct or incorrect. You then need to explain the reason for your answer. An example has been done for you:

In a vacuum, a 2.0 kg object will fall faster towards the ground than an object of mass 1.0 kg.

This statement is **incorrect**.
Explanation: **All objects falling towards the Earth in a vacuum have the same acceleration**.

(a) The mass of a particle (e.g. electron) remains constant as its speed approaches the speed of light.

This statement is ....

Explanation: ....

....

.... **[2]**

(b) A ball is thrown vertically upwards. Air resistance has negligible effect on its motion. During the flight, the total energy of the ball remains constant.

This statement is ....

Explanation: ....

....

.... **[2]**

(c) An object falling through air has a terminal velocity of $30\,m\,s^{-1}$. At terminal velocity, the weight of the object is equal to the acceleration of free fall.

This statement is ....

Explanation: ....

....

.... **[2]**

(d) The technique of 'triangle of vectors' is used by a global positioning system (GPS) to locate the position of cars.

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

This statement is ....

Explanation: ....

....

.... **[2]**

[Total: 8]

6 **(a)** Explain in terms of forces what is meant by a *couple*.

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

....

....

.... **[1]**

(b) **(i)** Define *moment of a force*.

....

.... **[1]**

(ii) Fig. 6.1 shows three forces acting on a rod.

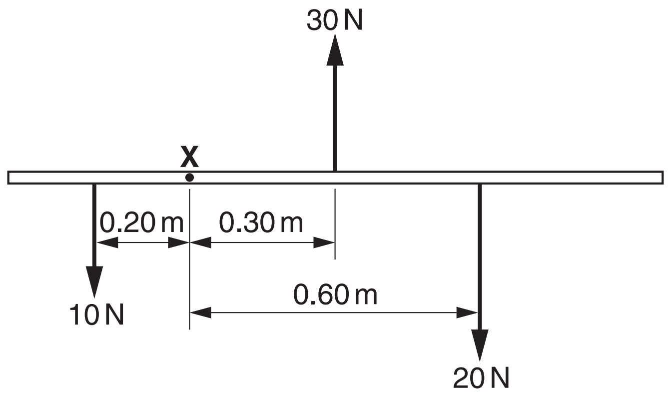


Fig. 6.1

By taking moments about point **X**, show that the rod is not in equilibrium when acted upon by these forces.

....

.... **[2]**

[Total: 4]

Turn over

7 **(a)** Fig. 7.1 shows stress against strain graphs for materials **X**, **Y** and **Z** up to their breaking points.

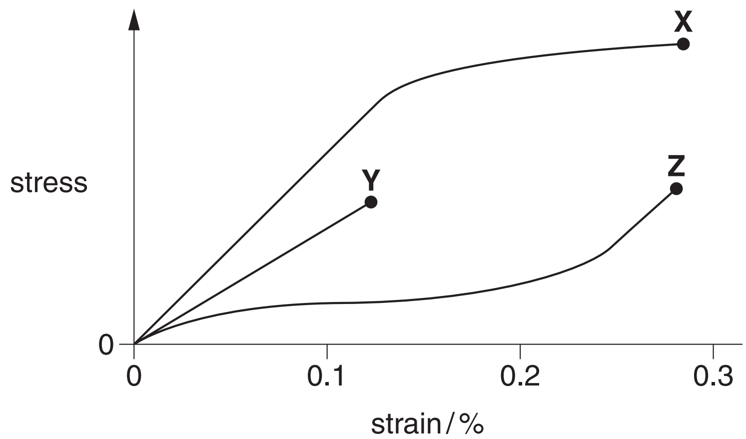


Fig. 7.1

(i) State which of these three materials is brittle.

.... **[1]**

(ii) State one similarity between the properties of materials **X** and **Y** for strains less than 0.05%.

....

.... **[1]**

(iii) State and explain which material has the greatest value for the Young modulus.

....

....

.... **[2]**

(b) Engineers are testing a new material to be used as support cables for a bridge. In a laboratory test, the breaking force for a sample of the material of diameter 0.50 mm is 240 N. Estimate the breaking force for a cable of diameter 15 mm made from the same material.

breaking force = ... N **[2]**

[Total: 6]

Please turnover for Question 8.

Turn over

8 A small block of wood is held at a horizontal distance of 1.2 m from a metal ball. The metal ball is fired horizontally towards the block at a speed of 8.0 m s^{-1}. At the same instant the ball is fired, the block is released and it falls vertically under gravity.

Fig. 8.1 shows the paths of the metal ball and the block. The ball collides with the block. Air resistance is negligible.

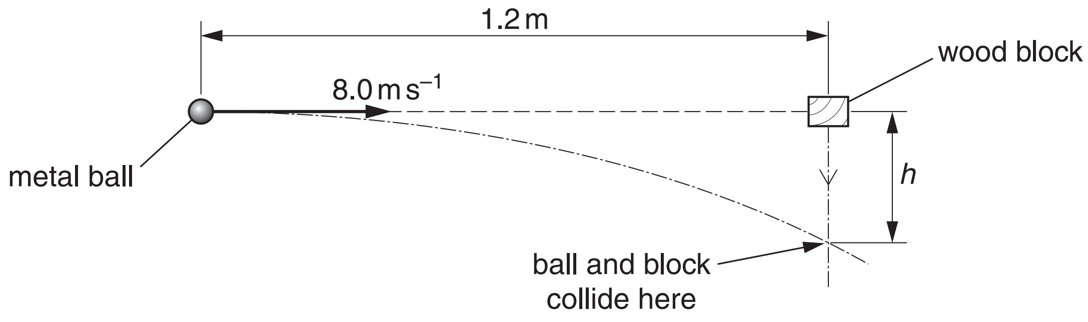


Fig. 8.1

(a) Show that the time between firing the ball and it colliding with the block is 0.15 s.

[1]

(b) Calculate the vertical distance *h* fallen by the wooden block when it collides with the metal ball.

h = ... m **[2]**

(c) Briefly explain why the metal ball will always collide with the wood block, even if the speed of the ball or the horizontal distance is changed.

....

....

.... **[1]**

[Total: 4]

END OF QUESTION PAPER