Q1.

1 **(a)** State the difference between a scalar quantity and a vector quantity.

scalar: ....

....

vector: ....

.... [2]

(b) Two forces of magnitude 6.0 N and 8.0 N act at a point P. Both forces act away from point P and the angle between them is 40°.
Fig. 1.1 shows two lines at an angle of 40° to one another.

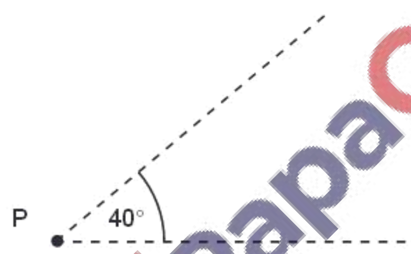


Fig. 1.1

On Fig. 1.1, draw a vector diagram to determine the magnitude of the resultant of the two forces.

magnitude of resultant = ... N [4]

Q2.

4 A ball has mass *m*. It is dropped onto a horizontal plate as shown in Fig. 4.1.

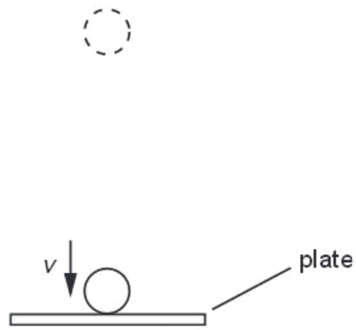


Fig. 4.1

Just as the ball makes contact with the plate, it has velocity *v*, momentum *p* and kinetic energy E_k.

(a) **(i)** Write down an expression for momentum *p* in terms of *m* and *v*.

....

(ii) Hence show that the kinetic energy is given by the expression

$$E_k = \frac{p^2}{2m}.$$

[3]

(b) Just before impact with the plate, the ball of mass 35 g has speed 4.5 m s^{-1}. It bounces from the plate so that its speed immediately after losing contact with the plate is 3.5 m s^{-1}. The ball is in contact with the plate for 0.14 s.

Calculate, for the time that the ball is in contact with the plate,

(i) the average force, in addition to the weight of the ball, that the plate exerts on the ball,

magnitude of force = ... N

direction of force = ... [4]

(ii) the loss in kinetic energy of the ball.

loss = ... J [2]

(c) State and explain whether linear momentum is conserved during the bounce.

....

....

....

.... [3]

Q3.

5 Two forces, each of magnitude *F*, form a couple acting on the edge of a disc of radius *r*, as shown in Fig. 5.1.

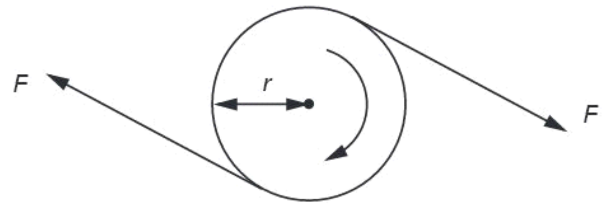


Fig. 5.1

(a) The disc is made to complete *n* revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) the distance moved by a point on the circumference of the disc,

distance = ...

(ii) the work done by one of the two forces.

work done = ...
[2]

(b) Using your answer to **(a)**, show that the work *W* done by a couple producing a torque *T* when it turns through *n* revolutions is given by

$$W = 2\pi nT.$$ [2]

(c) A car engine produces a torque of 470 N m at 2400 revolutions per minute. Calculate the output power of the engine.

power = ... W [2]

Use

Q4.

3 A bullet of mass 2.0 g is fired horizontally into a block of wood of mass 600 g. The block is suspended from strings so that it is free to move in a vertical plane.
The bullet buries itself in the block. The block and bullet rise together through a vertical distance of 8.6 cm, as shown in Fig. 3.1.

For Examiner's Use

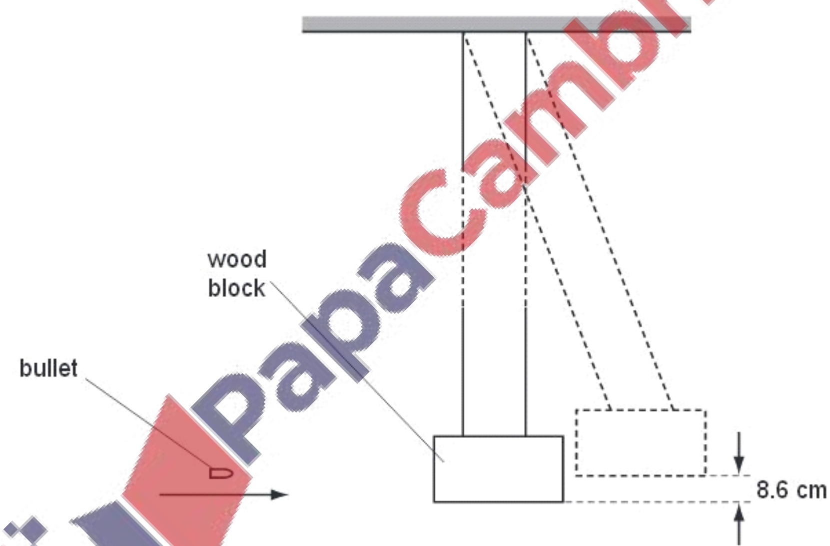


Fig. 3.1

(a) **(i)** Calculate the change in gravitational potential energy of the block and bullet.

change = ... J [2]

(ii) Show that the initial speed of the block and the bullet, after they began to move off together, was 1.3 m s^{-1}.

[1]

(b) Using the information in **(a)(ii)** and the principle of conservation of momentum, determine the speed of the bullet before the impact with the block.

speed = ... m s^{-1} [2]

(c) **(i)** Calculate the kinetic energy of the bullet just before impact.

kinetic energy = ... J [2]

(ii) State and explain what can be deduced from your answers to **(c)(i)** and **(a)(i)** about the type of collision between the bullet and the block.

....

....

....[2]

Q5.

Use

2 A rod AB is hinged to a wall at A. The rod is held horizontally by means of a cord BD, attached to the rod at end B and to the wall at D, as shown in Fig. 2.1.

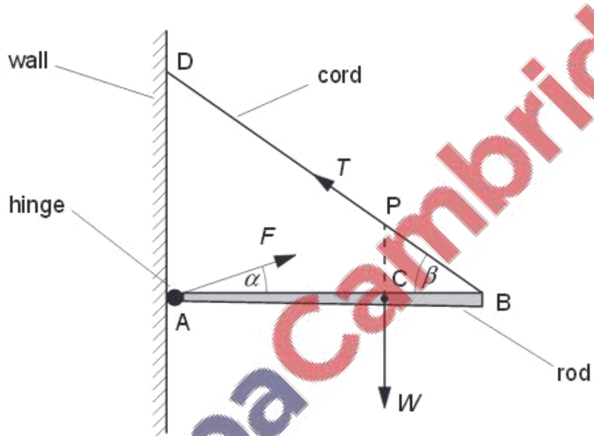


Fig. 2.1

The rod has weight W and the centre of gravity of the rod is at C. The rod is held in equilibrium by a force T in the cord and a force F produced at the hinge.

(a) Explain what is meant by

(i) the *centre of gravity* of a body,

....

....

.... [2]

(ii) the *equilibrium* of a body.

....

....

....

.... [2]

(b) The line of action of the weight *W* of the rod passes through the cord at point P.

Explain why, for the rod to be in equilibrium, the force *F* produced at the hinge must also pass through point P.

....

....

....

.... [2]

(c) The forces *F* and *T* make angles α and β respectively with the rod and AC = $\frac{3}{4}$AB, as shown in Fig. 2.1.

Write down equations, in terms of *F*, *W*, *T*, α and β, to represent

(i) the resolution of forces horizontally,

.... [1]

(ii) the resolution of forces vertically,

.... [1]

(iii) the taking of moments about A.

.... [1]

Q6.

3 A shopping trolley and its contents have a total mass of 42 kg. The trolley is being pushed along a horizontal surface at a speed of $1.2\,m\,s^{-1}$. When the trolley is released, it travels a distance of 1.9 m before coming to rest.

For Examiner's Use

(a) Assuming that the total force opposing the motion of the trolley is constant,

(i) calculate the deceleration of the trolley,

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

(ii) show that the total force opposing the motion of the trolley is 16 N.

[1]

(b) Using the answer in **(a)(ii)**, calculate the power required to overcome the total force opposing the motion of the trolley at a speed of $1.2\,m\,s^{-1}$.

power = ... W [2]

(c) The trolley now moves down a straight slope that is inclined at an angle of 2.8° to the horizontal, as shown in Fig. 3.1.

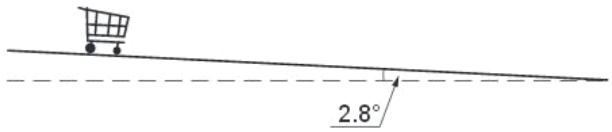


Fig. 3.1

The constant force that opposes the motion of the trolley is 16 N.

Calculate, for the trolley moving down the slope,

(i) the component down the slope of the trolley's weight,

component of weight = ... N [2]

(ii) the time for the trolley to travel from rest a distance of 3.5 m along the length of the slope.

time = ... s [4]

(d) Use your answer to **(c)(ii)** to explain why, for safety reasons, the slope is not made any steeper.

....

....[1]

Q7.

2 A spring is placed on a flat surface and different weights are placed on it, as shown in Fig. 2.1.

For Examiner's Use

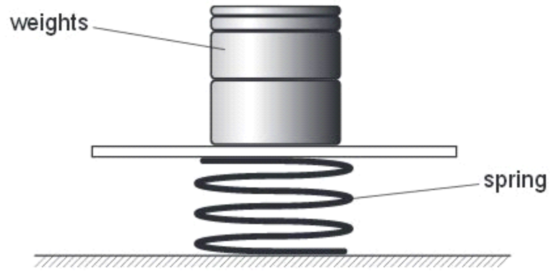


Fig. 2.1

The variation with weight of the compression of the spring is shown in Fig. 2.2.

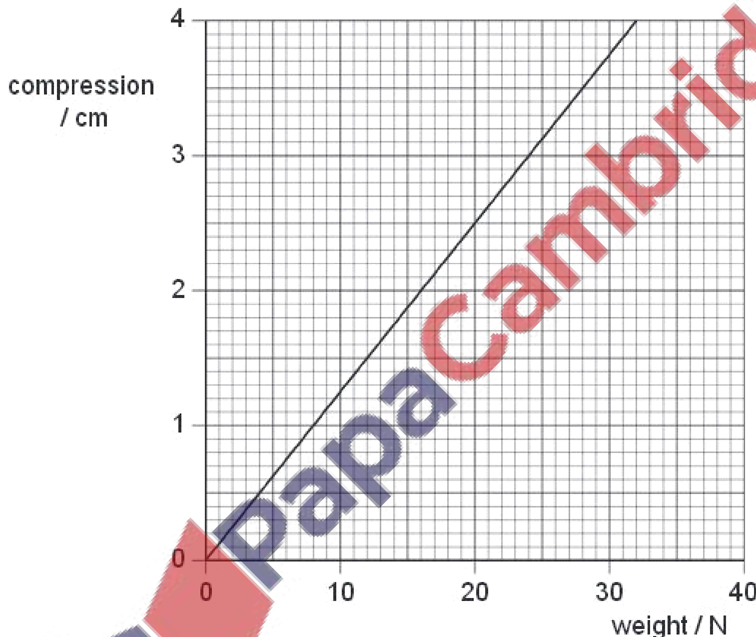


Fig. 2.2

The elastic limit of the spring has not been exceeded.

(a) **(i)** Determine the spring constant *k* of the spring.

k = ... $N m^{-1}$ [2]

(ii) Deduce that the strain energy stored in the spring is 0.49 J for a compression of 3.5 cm.

For Examiner's Use

[2]

(b) Two trolleys, of masses 800 g and 2400 g, are free to move on a horizontal table. The spring in **(a)** is placed between the trolleys and the trolleys are tied together using thread so that the compression of the spring is 3.5 cm, as shown in Fig. 2.3.

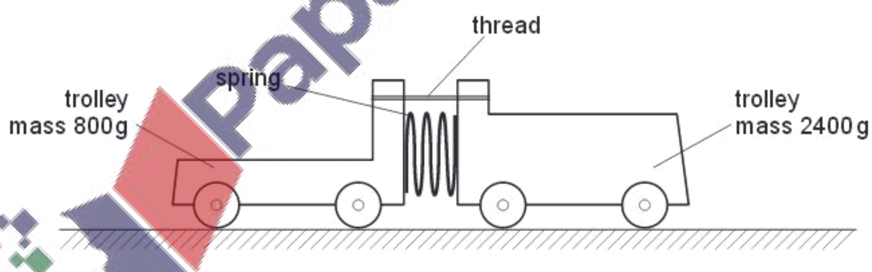


Fig. 2.3

Initially, the trolleys are not moving.
The thread is then cut and the trolleys move apart.

(i) Deduce that the ratio

$$\frac{\text{speed of trolley of mass 800 g}}{\text{speed of trolley of mass 2400 g}}$$

is equal to 3.0.

[2]

(ii) Use the answers in **(a)(ii)** and **(b)(i)** to calculate the speed of the trolley of mass 800 g.

For Examiner's Use

speed = ... m s^{-1} [3]

Q8.

2 A ball B of mass 1.2 kg travelling at constant velocity collides head-on with a stationary ball S of mass 3.6 kg, as shown in Fig. 2.1.

For Examiner's Use

Fig. 2.1

Frictional forces are negligible.

The variation with time *t* of the velocity *v* of ball B before, during and after colliding with ball S is shown in Fig. 2.2.

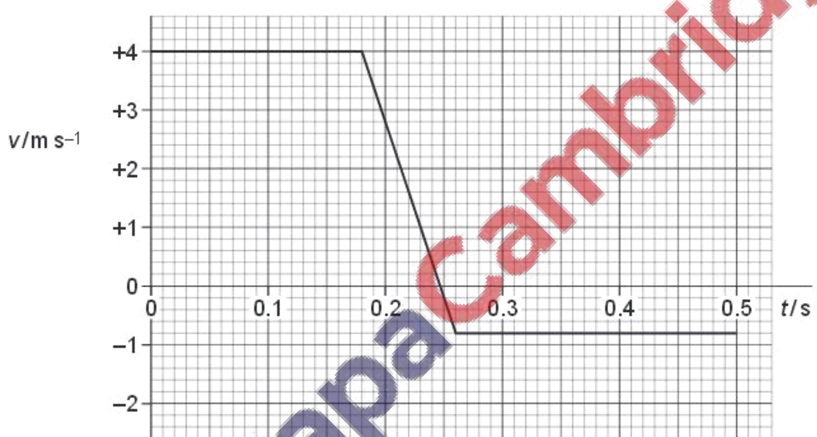


Fig. 2.2

(a) State the significance of positive and negative values for *v* in Fig. 2.2.

....

.... [1]

(b) Use Fig. 2.2 to determine, for ball B during the collision with ball S,

(i) the change in momentum of ball B,

change in momentum = ... N s [3]

(ii) the magnitude of the force acting on ball B.

force = ... N [3]

(c) Calculate the speed of ball S after the collision.

speed = ... m s^{-1} [2]

(d) Using your answer in **(c)** and information from Fig. 2.2, deduce quantitatively whether the collision is elastic or inelastic.

F
Exam
U

....

.... [2]

Q9.

3 **(a)** Define the *torque* of a couple.

For Examiner's Use

....

....

.... [2]

(b) A torque wrench is a type of spanner for tightening a nut and bolt to a particular torque, as illustrated in Fig. 3.1.

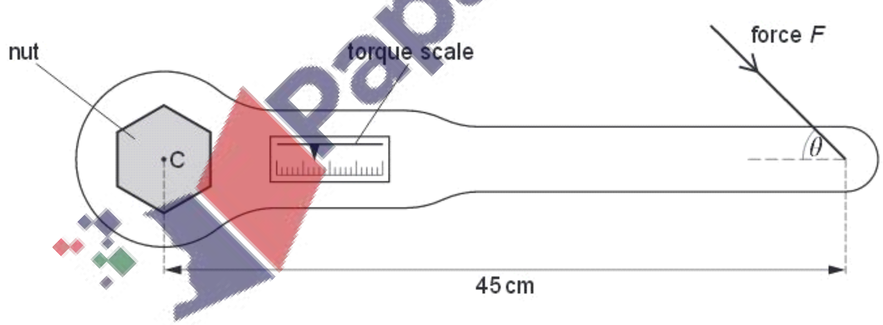


Fig. 3.1

The wrench is put on the nut and a force is applied to the handle. A scale indicates the torque applied.

The wheel nuts on a particular car must be tightened to a torque of 130 N m. This is achieved by applying a force *F* to the wrench at a distance of 45 cm from its centre of rotation C. This force *F* may be applied at any angle θ to the axis of the handle, as shown in Fig. 3.1.

For the minimum value of *F* to achieve this torque,

(i) state the magnitude of the angle θ that should be used,

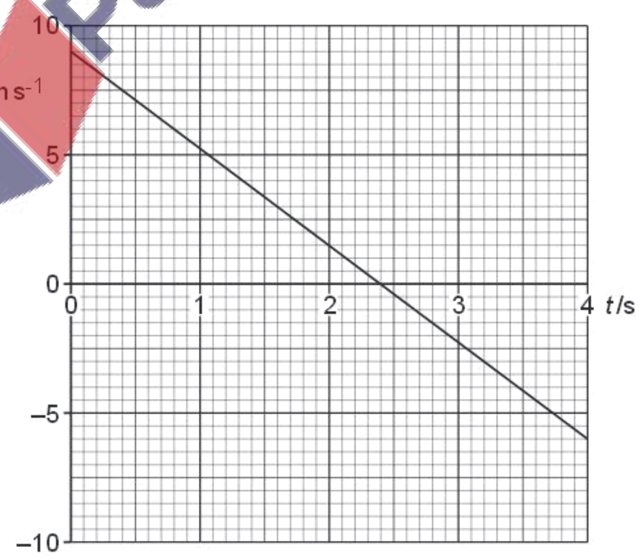
θ = ... ° [1]

(ii) calculate the magnitude of *F*.

F = ... N [2]

Q10.

2 An experiment is conducted on the surface of the planet Mars.
A sphere of mass 0.78 kg is projected almost vertically upwards from the surface of the planet. The variation with time *t* of the vertical velocity *v* in the upward direction is shown in Fig. 2.1.



The sphere lands on a small hill at time t = 4.0 s.

(a) State the time t at which the sphere reaches its maximum height above the planet's surface.

t = ... s [1]

(b) Determine the vertical height above the point of projection at which the sphere finally comes to rest on the hill.

height = ... m [3]

(c) Calculate, for the first 3.5 s of the motion of the sphere,

(i) the change in momentum of the sphere,

change in momentum = ... N s [2]

(ii) the force acting on the sphere.

force = ...N [2]

(d) Using your answer in **(c)(ii)**,

(i) state the weight of the sphere,

weight = ...N [1]

(ii) determine the acceleration of free fall on the surface of Mars.

acceleration = ... ms^{-2} [2]

Q11.

3 **(a)** The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

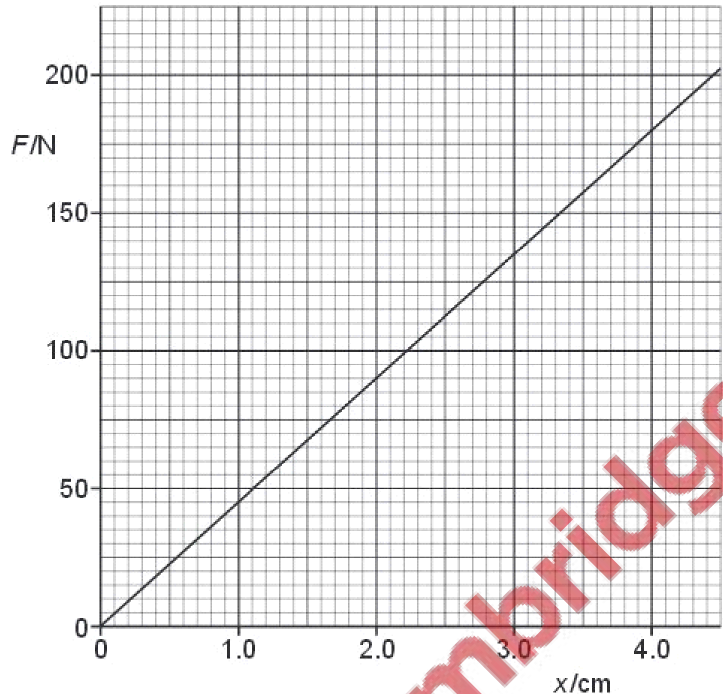


Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm. Explain your working.

energy = ... J [3]

(b) The spring in **(a)** is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

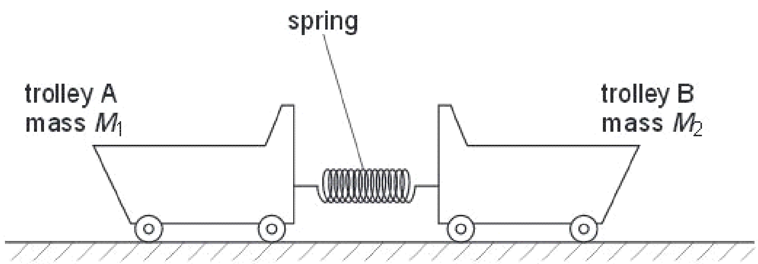


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

(i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

....

....

....

....[2]

(ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2.
Write down

1. an equation, based on momentum, to relate V_1 and V_2,

....

....[1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

....

....[1]

Q12.

3 (a) (i) Define *force*.

....

....[1]

(ii) State Newton's third law of motion.

....

....

....

....[3]

(b) Two spheres approach one another along a line joining their centres, as illustrated in Fig. 3.1.

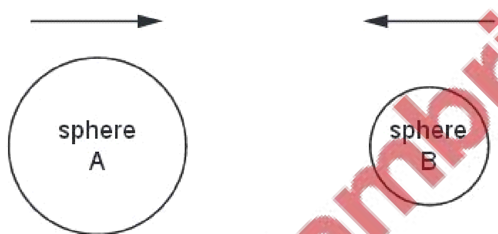


Fig. 3.1

When they collide, the average force acting on sphere A is F_A and the average force acting on sphere B is F_B.

The forces act for time t_A on sphere A and time t_B on sphere B.

(i) State the relationship between

1. F_A and F_B,

....[1]

2. t_A and t_B.

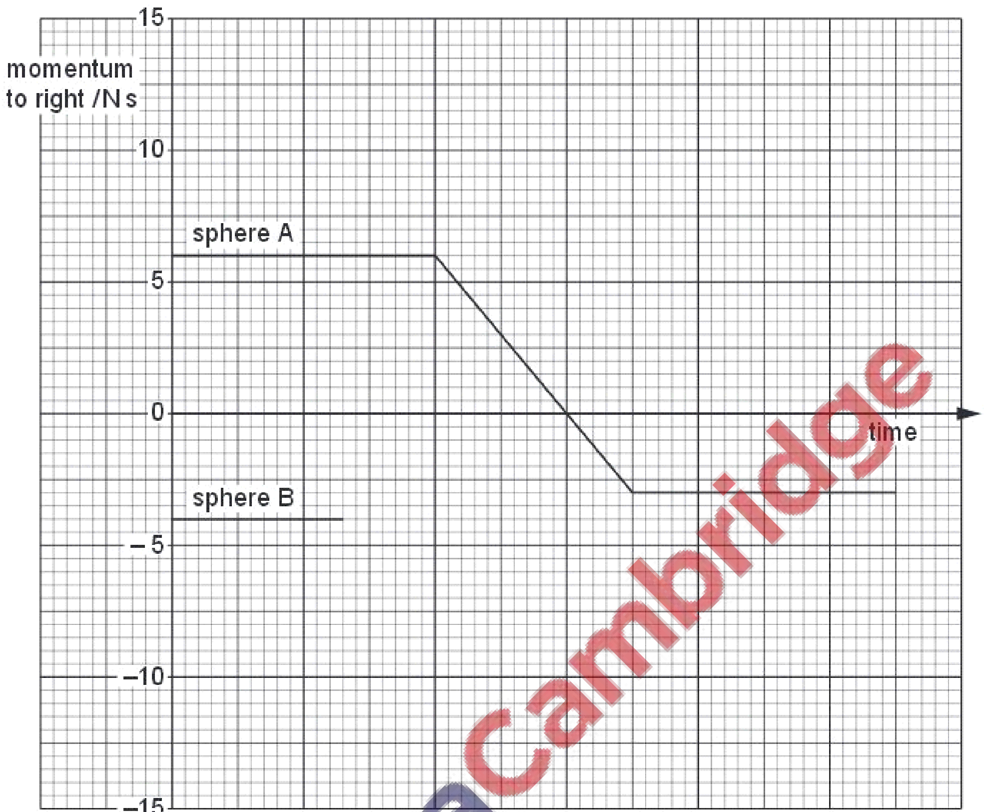
....[1]

(ii) Use your answers in **(i)** to show that the change in momentum of sphere A is equal in magnitude and opposite in direction to the change in momentum of sphere B.

....

....[1]

(c) For the spheres in **(b)**, the variation with time of the momentum of sphere A before, during and after the collision with sphere B is shown in Fig. 3.2.



The momentum of sphere B before the collision is also shown on Fig. 3.2.

Complete Fig. 3.2 to show the variation with time of the momentum of sphere B during and after the collision with sphere A. [3]

Q13.

2 (a) State the two conditions that must be satisfied for a body to be in equilibrium.

1. ....

....

2. ....

.... [2]

(b) Three co-planar forces act on a body that is in equilibrium.

(i) Describe how to draw a vector triangle to represent these forces.

....

....

....

....

....

....

....[3]

(ii) State how the triangle confirms that the forces are in equilibrium.

....

....[1]

(c) A weight of 7.0 N hangs vertically by two strings AB and AC, as shown in Fig. 2.1.

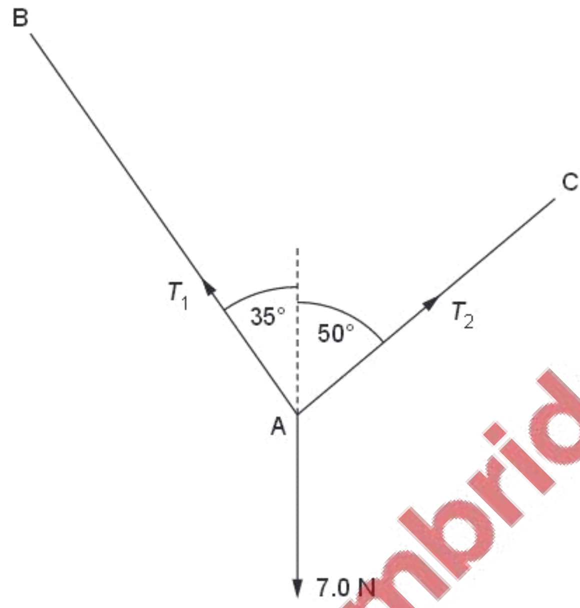


Fig. 2.1

For the weight to be in equilibrium, the tension in string AB is T_1 and in string AC it is T_2.

On Fig. 2.1, draw a vector triangle to determine the magnitudes of T_1 and T_2.

T_1 = ... N

T_2 = ... N
[3]

(d) By reference to Fig. 2.1, suggest why the weight could not be supported with the strings AB and AC both horizontal.

....

....[2]

Q14.

3 **(a)** Explain what is meant by *centre of gravity*.

....

.... [2]

(b) Define *moment* of a force.

....

.... [1]

(c) A student is being weighed. The student, of weight W, stands 0.30 m from end A of a uniform plank AB, as shown in Fig. 3.1.

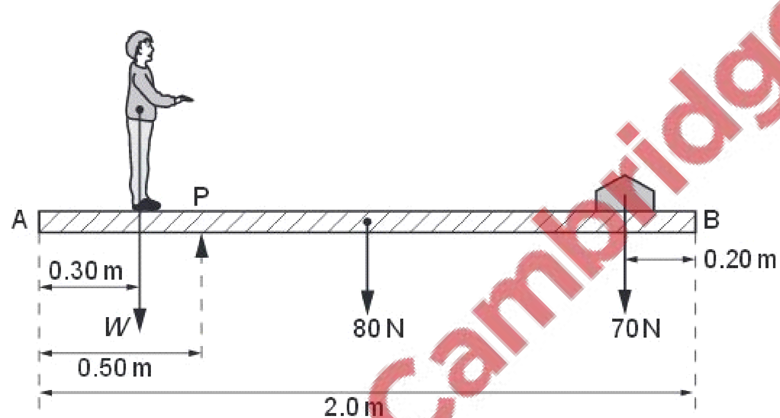


Fig. 3.1 (not to scale)

The plank has weight 80 N and length 2.0 m. A pivot P supports the plank and is 0.50 m from end A.
A weight of 70 N is moved to balance the weight of the student. The plank is in equilibrium when the weight is 0.20 m from end B.

(i) State the two conditions necessary for the plank to be in equilibrium.

1. ....

....

2. ....

....
[2]

(ii) Determine the weight W of the student.

W = ... N [3]

(iii) If only the 70 N weight is moved, there is a maximum weight of student that can be determined using the arrangement shown in Fig. 3.1. State and explain **one** change that can be made to increase this maximum weight.

....

....

.... [2]

Q15.

2 A climber is supported by a rope on a vertical wall, as shown in Fig. 2.1.

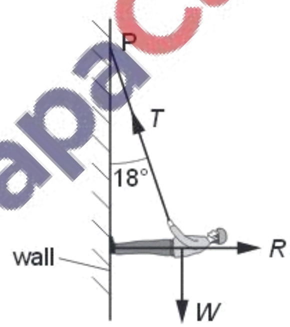


Fig. 2.1

The weight W of the climber is 520 N. The rope, of negligible weight, is attached to the climber and to a fixed point P where it makes an angle of 18° to the vertical. The reaction force R acts at right-angles to the wall.
The climber is in equilibrium.

(a) State the conditions necessary for the climber to be in equilibrium.

....

....

....[2]

(b) Complete Fig. 2.2 by drawing a labelled vector triangle to represent the forces acting on the climber.

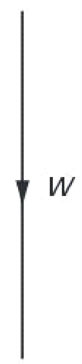


Fig. 2.2

[2]

(c) Resolve forces or use your vector triangle to calculate

(i) the tension *T* in the rope,

T = ... N [2]

(ii) the reaction force *R*.

R = ... N [1]

(d) The climber moves up the wall and the angle the rope makes with the vertical increases. Explain why the magnitude of the tension in the rope increases.

....

....

.... [1]

Q16.

3 A helicopter has a cable hanging from it towards the sea below, as shown in Fig. 3.1.

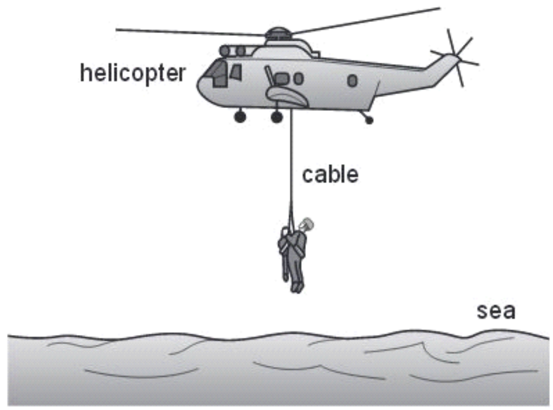


Fig. 3.1

A man of mass 80 kg rescues a child of mass 50.5 kg. The two are attached to the cable and are lifted from the sea to the helicopter. The lifting process consists of an initial uniform acceleration followed by a period of constant velocity and then completed by a final uniform deceleration.

(a) Calculate the combined weight of the man and child.

weight = ... N [1]

(b) Calculate the tension in the cable during

(i) the initial acceleration of 0.570 m s^{-2},

tension = ... N [2]

(ii) the period of constant velocity of 2.00 m s^{-1}.

tension = ... N [1]

(c) During the final deceleration the tension in the cable is 1240 N. Calculate this deceleration.

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

(d) **(i)** Calculate the time over which the man and child are

1. moving with uniform acceleration,

time = ... s [1]

2. moving with uniform deceleration.

time = ... s [1]

(ii) The time over which the man and child are moving with constant velocity is 20 s. On Fig. 3.2, sketch a graph to show the variation with time of the velocity of the man and child for the complete lifting process.

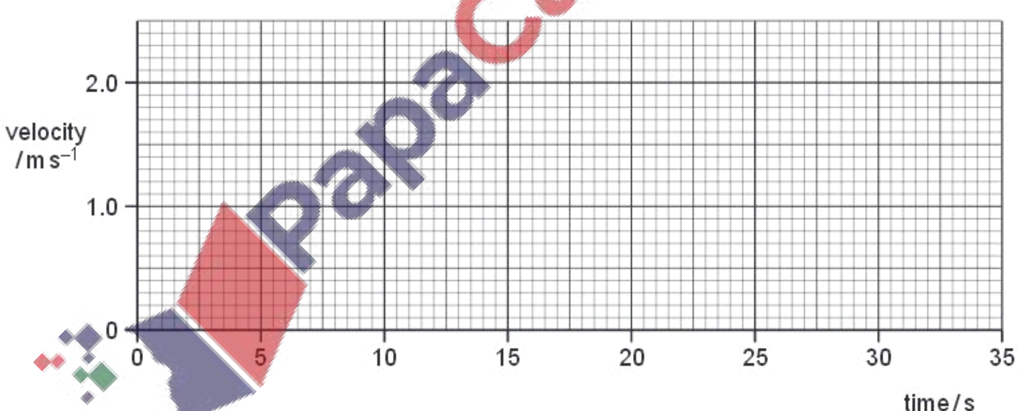


Fig. 3.2

[2]

Q17.

2 A ball is thrown vertically down towards the ground with an initial velocity of $4.23\,\mathrm{m\,s^{-1}}$. The ball falls for a time of 1.51 s before hitting the ground. Air resistance is negligible.

(a) **(i)** Show that the downwards velocity of the ball when it hits the ground is $19.0\,\mathrm{m\,s^{-1}}$.

[2]

(ii) Calculate, to three significant figures, the distance the ball falls to the ground.

distance = ... m [2]

(b) The ball makes contact with the ground for 12.5 ms and rebounds with an upwards velocity of $18.6\,\mathrm{m\,s^{-1}}$. The mass of the ball is 46.5 g.

(i) Calculate the average force acting on the ball on impact with the ground.

magnitude of force = ... N

direction of force ....

[4]

(ii) Use conservation of energy to determine the maximum height the ball reaches after it hits the ground.

height = ... m [2]

(c) State and explain whether the collision the ball makes with the ground is elastic or inelastic.

....

....

....[1]

Q18.

3 **(a)** State Newton's first law.

....

.... [1]

(b) A log of mass 450 kg is pulled up a slope by a wire attached to a motor, as shown in Fig. 3.1.

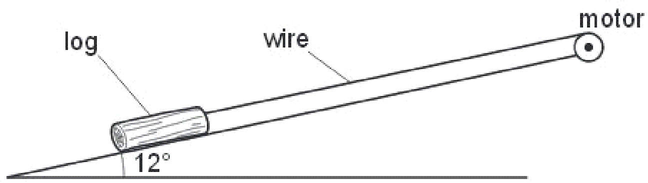


Fig. 3.1

The angle that the slope makes with the horizontal is 12°. The frictional force acting on the log is 650 N. The log travels with constant velocity.

(i) With reference to the motion of the log, discuss whether the log is in equilibrium.

....

....

....

.... [2]

(ii) Calculate the tension in the wire.

tension = ... N [3]

(iii) State and explain whether the gain in the potential energy per unit time of the log is equal to the output power of the motor.

....

....

....

.... [2]

Q19.

1 **(a)** Explain the differences between the quantities *distance* and *displacement*.

....

....

.... [2]

(b) State Newton's first law.

....

....

.... [1]

(c) Two tugs pull a tanker at constant velocity in the direction XY, as represented in Fig. 1.1.

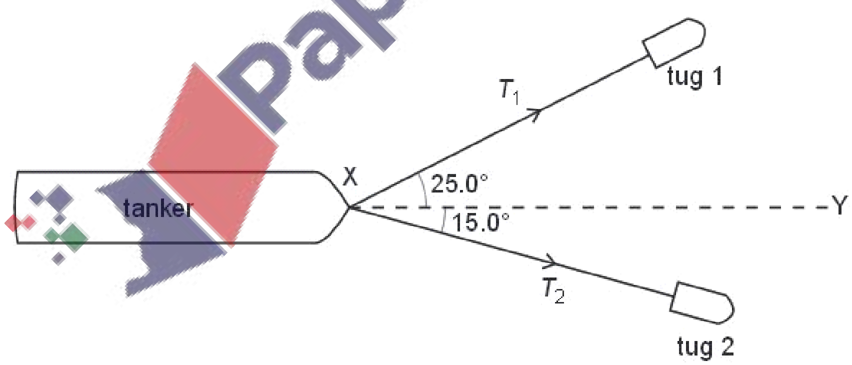


Fig. 1.1

Tug 1 pulls the tanker with a force T_1 at 25.0° to XY. Tug 2 pulls the tanker with a force of T_2 at 15.0° to XY. The resultant force R due to the two tugs is 25.0×10^3 N in the direction XY.

(i) By reference to the forces acting on the tanker, explain how the tanker may be described as being in equilibrium.

....

....

....

....[2]

(ii) 1. Complete Fig. 1.2 to draw a vector triangle for the forces *R*, T_1 and T_2. [2]

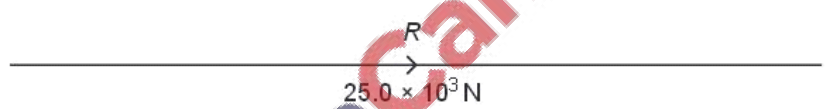


Fig. 1.2

2. Use your vector triangle in Fig. 1.2 to determine the magnitude of T_1 and of T_2.

T_1 = ... N

T_2 = ... N
[2]

Q20.

2 A motor drags a log of mass 452 kg up a slope by means of a cable, as shown in Fig. 2.1.

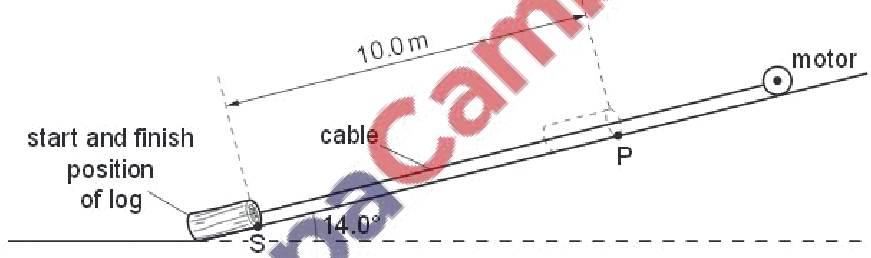


Fig. 2.1

The slope is inclined at 14.0° to the horizontal.

(a) Show that the component of the weight of the log acting down the slope is 1070 N.

[1]

(b) The log starts from rest. A constant frictional force of 525 N acts on the log. The log accelerates up the slope at 0.130 m s^{-2}.

(i) Calculate the tension in the cable.

tension = ... N [3]

(ii) The log is initially at rest at point S. It is pulled through a distance of 10.0 m to point P.

Calculate, for the log,

1. the time taken to move from S to P,

time = ... s [2]

2. the magnitude of the velocity at P.

velocity = ... m s^{-1} [1]

(c) The cable breaks when the log reaches point P. On Fig. 2.2, sketch the variation with time *t* of the velocity *v* of the log. The graph should show *v* from the start at S until the log returns to S. **[4]**

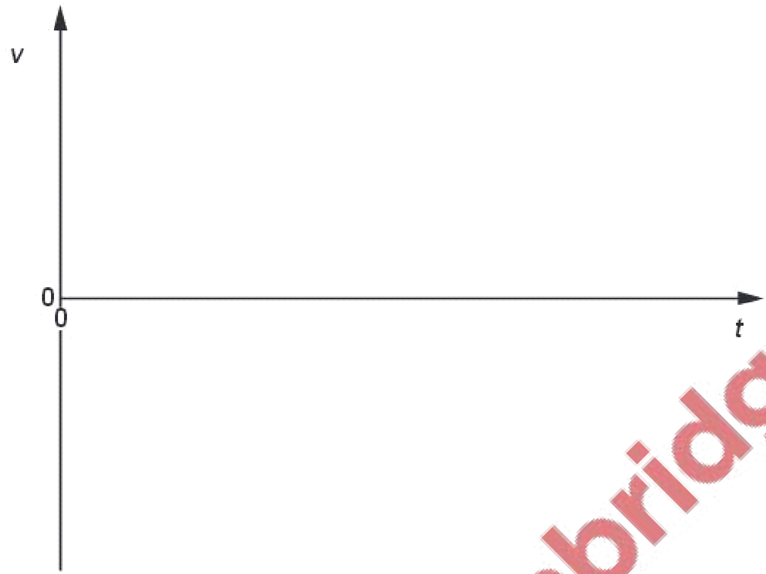


Fig. 2.2

Q21.

2 **(a)** Distinguish between *mass and weight*.

mass: ....

....

weight: ....

....

[2]

(b) An object O of mass 4.9 kg is suspended by a rope A that is fixed at point P. The object is pulled to one side and held in equilibrium by a second rope B, as shown in Fig. 2.1.

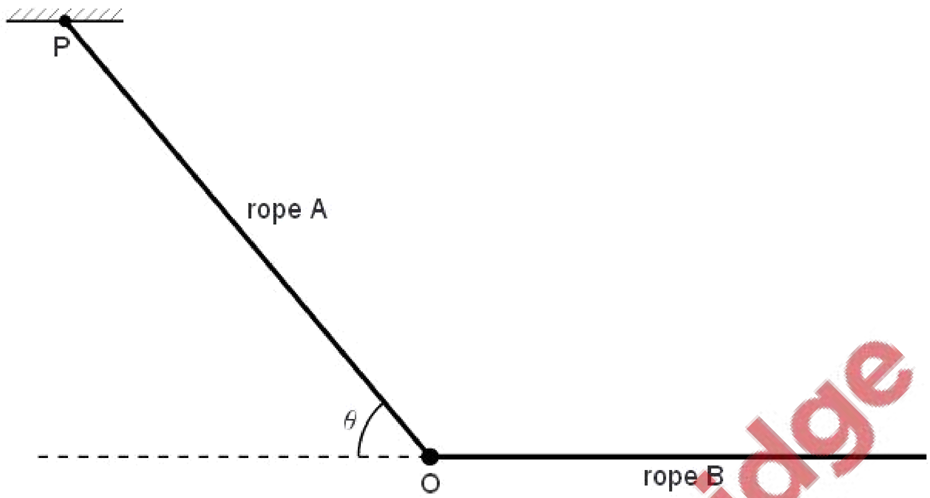


Fig. 2.1

Rope A is at an angle θ to the horizontal and rope B is horizontal. The tension in rope A is 69 N and the tension in rope B is T.

(i) On Fig. 2.1, draw arrows to represent the directions of all the forces acting on object O. [2]

(ii) Calculate

1. the angle θ,

θ = ...° [3]

2. the tension T.

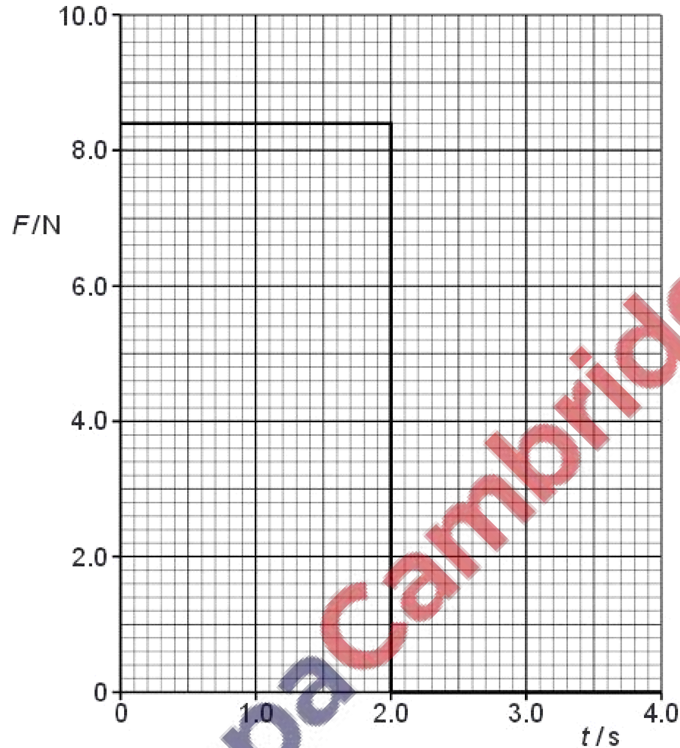
T = ...N [2]

Q22.

2 **(a)** Define *force*.

.... [1]

(b) A resultant force F acts on an object of mass 2.4 kg. The variation with time t of F is shown in Fig. 2.1.



The object starts from rest.

(i) On Fig. 2.2, show quantitatively the variation with t of the acceleration a of the object. Include appropriate values on the y-axis.

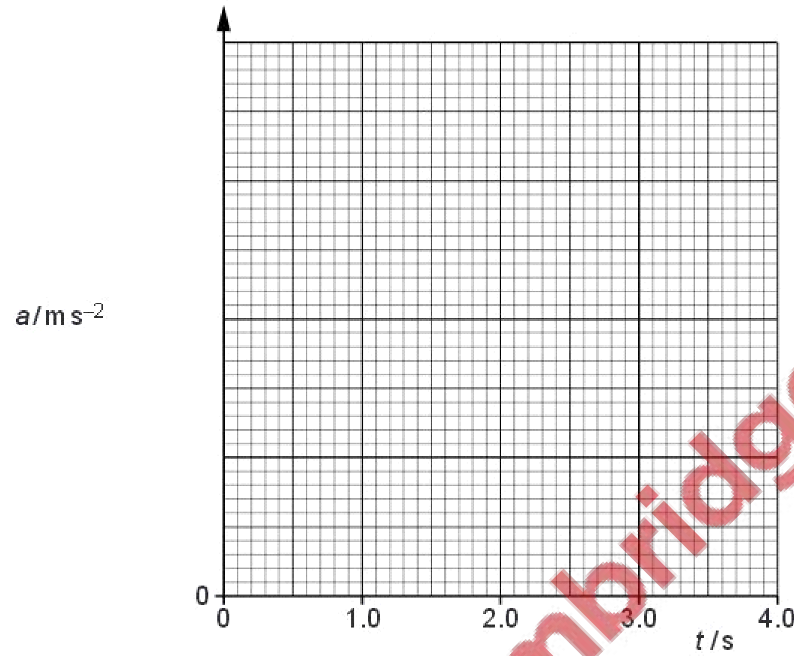


Fig. 2.2

[4]

(ii) On Fig. 2.3, show quantitatively the variation with t of the momentum p of the object. Include appropriate values on the y-axis.

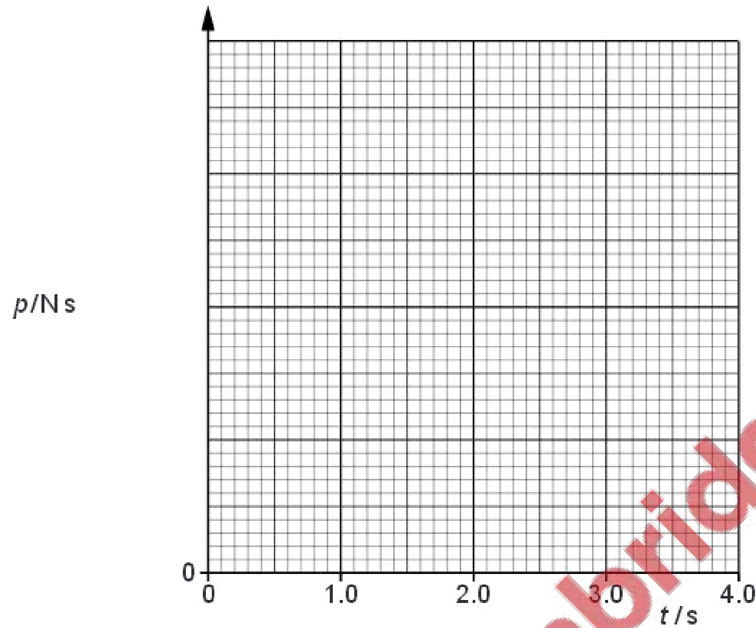


Fig. 2.3

[5]

Q23.

3 **(a)** Define *centre of gravity*.

....

....[2]

(b) A uniform rod AB is attached to a vertical wall at A. The rod is held horizontally by a string attached at B and to point C, as shown in Fig. 3.1.

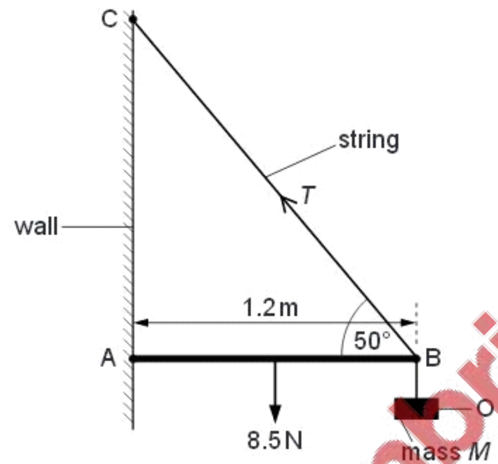


Fig. 3.1

The angle between the rod and the string at B is 50°. The rod has length 1.2 m and weight 8.5 N. An object O of mass *M* is hung from the rod at B. The tension *T* in the string is 30 N.

(i) Use the resolution of forces to calculate the vertical component of *T*.

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

(ii) State the *principle of moments*.

....

....[1]

(iii) Use the principle of moments and take moments about A to show that the weight of the object O is 19 N.

Fo Exami Us

[3]

(iv) Hence determine the mass M of the object O.

M = ... kg [1]

(c) Use the concept of equilibrium to explain why a force must act on the rod at A.

....

....

....[2]

Q24.

3 **(a)** **(i)** State the principle of conservation of momentum.

....

....

....[2]

(ii) State the difference between an elastic and an inelastic collision.

....[1]

(b) An object A of mass 4.2 kg and horizontal velocity $3.6\,\text{m s}^{-1}$ moves towards object B as shown in Fig. 3.1.

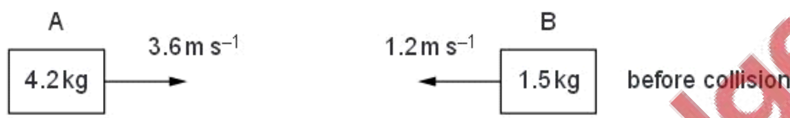


Fig. 3.1

Object B of mass 1.5 kg is moving with a horizontal velocity of $1.2\,\text{m s}^{-1}$ towards object A.

The objects collide and then both move to the right, as shown in Fig. 3.2.

Fig. 3.2

Object A has velocity *v* and object B has velocity $3.0\,\text{m s}^{-1}$.

(i) Calculate the velocity *v* of object A after the collision.

velocity = ... m s^{-1} [3]

(ii) Determine whether the collision is elastic or inelastic.

[3]

Q25.

2 **(a)** Distinguish between the mass of a body and its weight.

mass ....

....

weight ....

.... [3]

(b) State two situations where a body of constant mass may experience a change in its apparent weight.

1. ....

....

2. ....

.... [2]

Q26.

3 **(a)** Define the *moment* of a force.

....

.... [2]

(b) State the two conditions necessary for a body to be in equilibrium.

1. ....

....

2. ....

.... [2]

Use

(c) Two parallel strings S_1 and S_2 are attached to a disc of diameter 12 cm, as shown in Fig. 3.1.

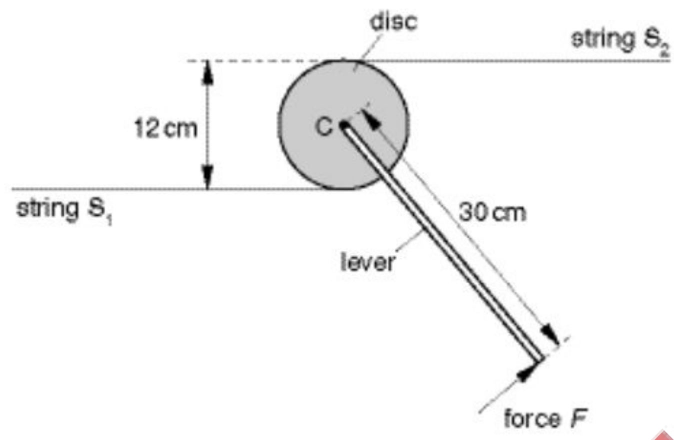


Fig. 3.1

The disc is free to rotate about an axis normal to its plane. The axis passes through the centre C of the disc.

A lever of length 30 cm is attached to the disc. When a force F is applied at right angles to the lever at its end, equal forces are produced in S_1 and S_2. The disc remains in equilibrium.

(i) On Fig. 3.1, show the direction of the force in each string that acts on the disc. [1]

(ii) For a force *F* of magnitude 150 N, determine

1. the moment of force *F* about the centre of the disc,

moment = ... N m

2. the torque of the couple produced by the forces in the strings,

torque = ... N m

3. the force in S_1.

force = ... N
[4]

Q27.

2 **(a)** Explain what is meant by the *centre of gravity* of a body.

....

....

.... [2]

(b) An irregularly-shaped piece of cardboard is hung freely from one point near its edge, as shown in Fig. 2.1.

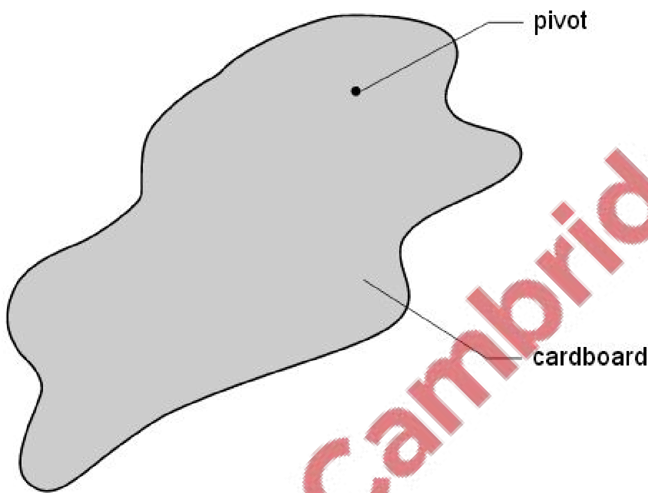


Fig. 2.1

Explain why the cardboard will come to rest with its centre of gravity vertically below the pivot. You may draw on Fig. 2.1 if you wish.

....

....

.... [2]

Q28.

3 A stone on a string is made to travel along a horizontal circular path, as shown in Fig. 3.1.

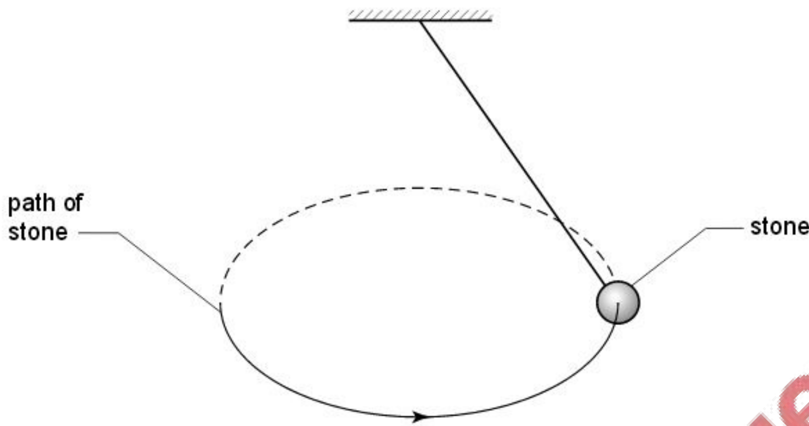


Fig. 3.1

The stone has a constant speed.

(a) Define *acceleration*.

....

.... [1]

(b) Use your definition to explain whether the stone is accelerating.

....

....

.... [2]

(c) The stone has a weight of 5.0 N. When the string makes an angle of 35° to the vertical, the tension in the string is 6.1 N, as illustrated in Fig. 3.2.

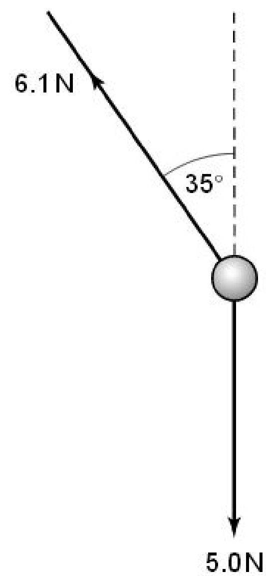


Fig. 3.2

Determine the resultant force acting on the stone in the position shown.

magnitude of force = ... N

direction of force... [4]

Q29.

4 A trolley of mass 930 g is held on a horizontal surface by means of two springs, as shown in Fig. 4.1.

For Examiner's Use

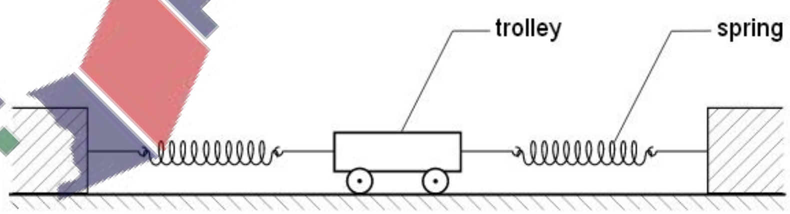


Fig. 4.1

The variation with time *t* of the speed *v* of the trolley for the first 0.60 s of its motion is shown in Fig. 4.2.

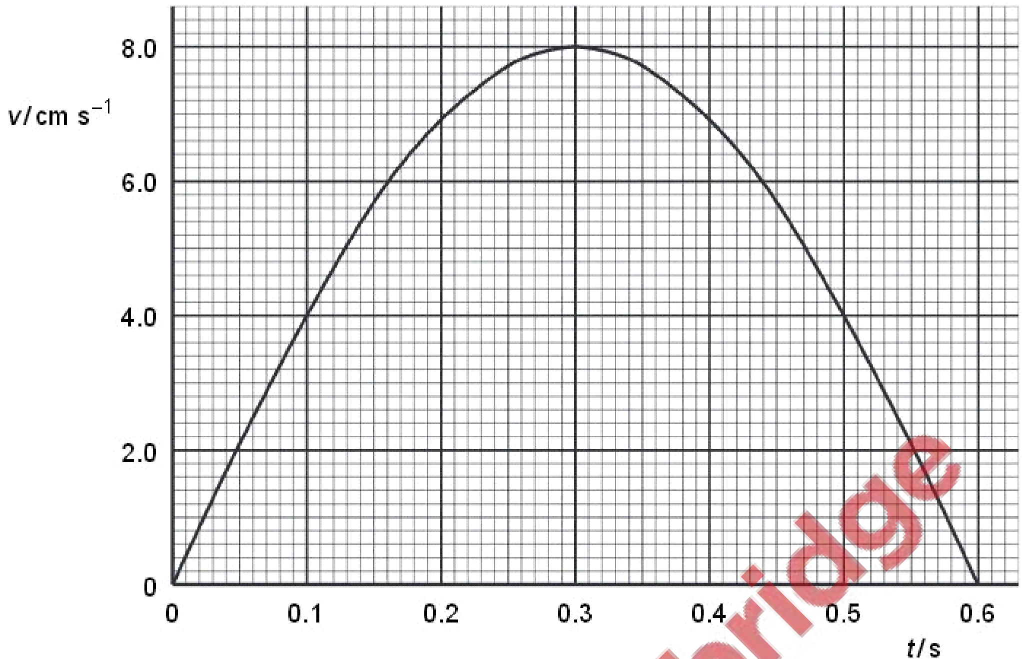


Fig. 4.2

(a) Use Fig. 4.2 to determine

(i) the initial acceleration of the trolley,

acceleration = ... m s^{-2} [2]

(ii) the distance moved during the first 0.60 s of its motion.

distance = ... m [3]

(b) (i) Use your answer to (a)(i) to determine the resultant force acting on the trolley at time $t = 0$.

force = ... N [2]

(ii) Describe qualitatively the variation with time of the resultant force acting on the trolley during the first 0.60 s of its motion.

....

....

....

.... [3]

Q30.

3 Francium-208 is radioactive and emits α-particles with a kinetic energy of 1.07×10^{-12} J to form nuclei of astatine, as illustrated in Fig. 3.1.

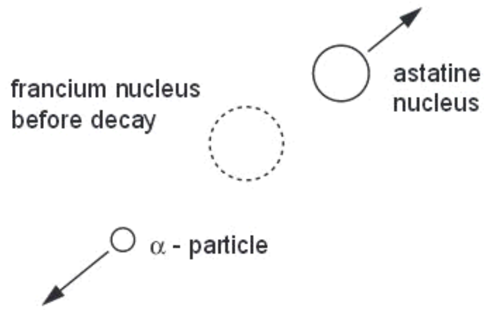


Fig. 3.1

(a) State the nature of an α-particle.

....

.... [1]

(b) Show that the initial speed of an α-particle after the decay of a francium nucleus is approximately 1.8×10^{7} m s^{-1}.

[2]

(c) **(i)** State the principle of conservation of linear momentum.

....

....

.... [2]

(ii) The Francium-208 nucleus is stationary before the decay. Estimate the speed of the astatine nucleus immediately after the decay.

For Examiner's Use

speed = ... m s^{-1} [3]

(d) Close examination of the decay of the francium nucleus indicates that the astatine nucleus and the α-particle are not ejected exactly in opposite directions.

Suggest an explanation for this observation.

....

....

.... [2]

Q31.

3 **(a)** Distinguish between the moment of a force and the torque of a couple.

Ex

moment of a force ....

....

....

torque of a couple ....

....

....

[4]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 3.1.

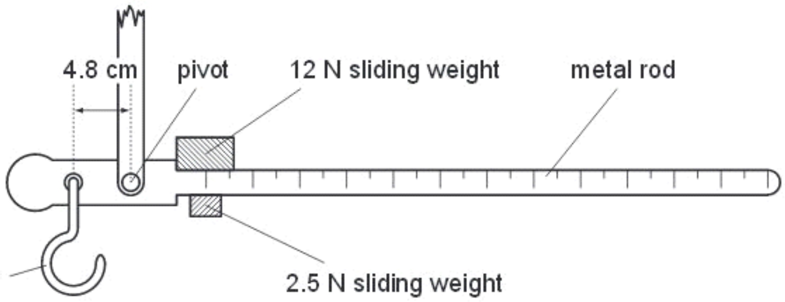


Fig. 3.1

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.

A sack of flour is suspended from the hook. In order to return the metal rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour.

weight = ...N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.

....

....[1]

Q32.

3 A stationary nucleus of mass 220u undergoes radioactive decay to produce a nucleus D of mass 216u and an α-particle of mass 4u, as illustrated in Fig. 3.1.

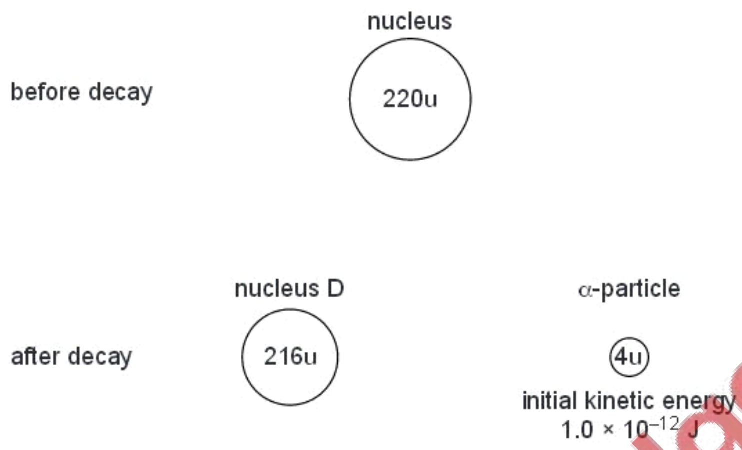


Fig. 3.1

The initial kinetic energy of the α-particle is 1.0×10^{-12} J.

(a) (i) State the law of conservation of linear momentum.

....

....

.... [2]

(ii) Explain why the initial velocities of the nucleus D and the α-particle must be in opposite directions.

....

....

.... [2]

(b) (i) Show that the initial speed of the α-particle is $1.7 \times 10^{7}\ \text{m s}^{-1}$.

[2]

(ii) Calculate the initial speed of nucleus D.

speed = ... m s^{-1} [2]

(c) The range in air of the emitted α-particle is 4.5 cm.
Calculate the average deceleration of the α-particle as it is stopped by the air.

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

Q33.

3 **(a)** State the relation between force and momentum.

.... [1]

For Examiner's Use

(b) A rigid bar of mass 450 g is held horizontally by two supports A and B, as shown in Fig. 3.1.

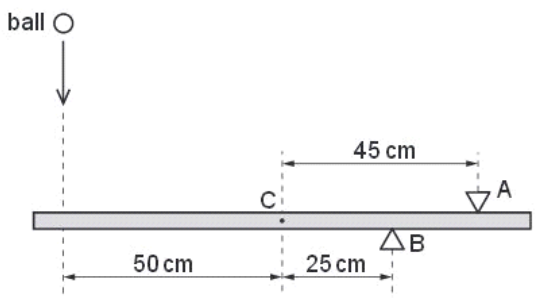
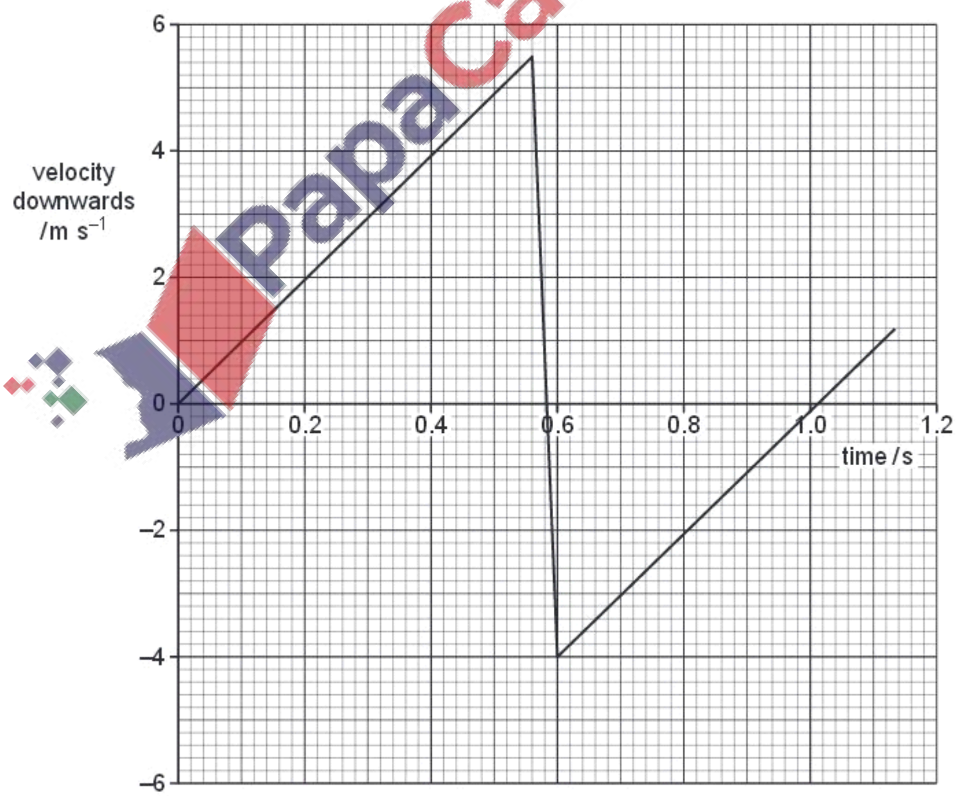


Fig. 3.1

The support A is 45 cm from the centre of gravity C of the bar and support B is 25 cm from C.

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm from C, as shown in Fig. 3.1.
The variation with time *t* of the velocity *v* of the ball before, during and after hitting the bar is shown in Fig. 3.2.



For the time that the ball is in contact with the bar, use Fig. 3.2

For Examiner Use

(i) to determine the change in momentum of the ball,

change = ... kg m s^{-1} [2]

(ii) to show that the force exerted by the ball on the bar is 33 N.

[1]

(c) For the time that the ball is in contact with the bar, use data from Fig. 3.1 and **(b)(ii)** to calculate the force exerted on the bar by

(i) the support A,

force = ... N [3]

(ii) the support B.

force = ... N [2]

Q34.

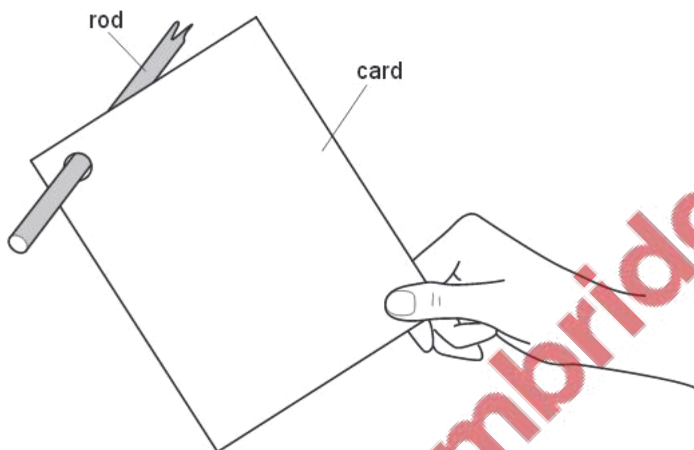
3 **(a)** State what is meant by the *centre of gravity* of a body.

....

....

....[2]

(b) A uniform rectangular sheet of card of weight *W* is suspended from a wooden rod. The card is held to one side, as shown in Fig. 3.1.



On Fig. 3.1,

(i) mark, and label with the letter C, the position of the centre of gravity of the card, [1]

(ii) mark with an arrow labelled *W* the weight of the card. [1]

(c) The card in **(b)** is released. The card swings on the rod and eventually comes to rest.

For Examiner's Use

(i) List the two forces, other than its weight and air resistance, that act on the card during the time that it is swinging. State where the forces act.

1. ....

....

2. ....

.... [3]

(ii) By reference to the completed diagram of Fig. 3.1, state the position in which the card comes to rest.
Explain why the card comes to rest in this position.

....

....

.... [2]

Q35.

2 (a) Define the *torque* of a couple.

....

.... [2]

(b) A uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

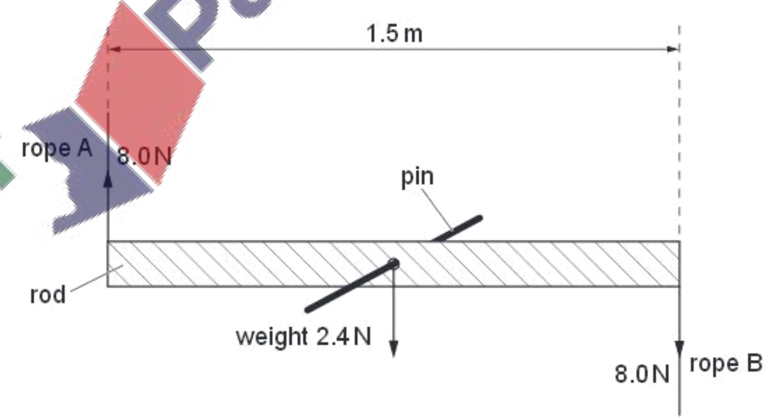


Fig. 2.1

The rod is supported on a pin passing through a hole in its centre. Ropes A and B provide equal and opposite forces of 8.0 N.

(i) Calculate the torque on the rod produced by ropes A and B.

torque = ... Nm [1]

(ii) Discuss, briefly, whether the rod is in equilibrium.

....

....

....

.... [2]

(c) The rod in **(b)** is removed from the pin and supported by ropes A and B, as shown in Fig. 2.2.

For Examiner's Use

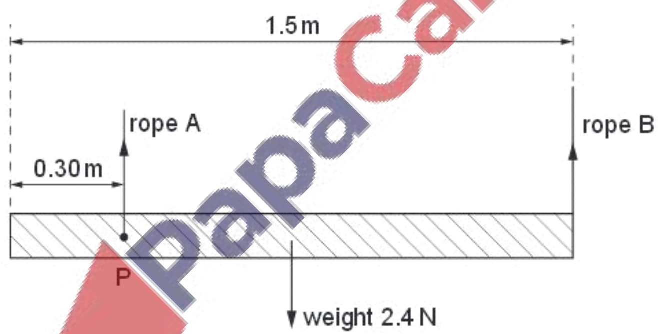


Fig. 2.2

Rope A is now at point P 0.30 m from one end of the rod and rope B is at the other end.

(i) Calculate the tension in rope B.

tension in B = ... N [2]

(ii) Calculate the tension in rope A.

tension in A = ... N [1]

Q36.

2 (a) Define

(i) *force*,

....

....[1]

(ii) *work done*.

....

....[1]

(b) A force F acts on a mass m along a straight line for a distance s. The acceleration of the mass is a and the speed changes from an initial speed u to a final speed v.

(i) State the work W done by F.

[1]

(ii) Use your answer in **(i)** and an equation of motion to show that kinetic energy of a mass can be given by the expression

kinetic energy = ½ × mass × (speed)^2.

[3]

(c) A resultant force of 3800 N causes a car of mass of 1500 kg to accelerate from an initial speed of 15 m s^{-1} to a final speed of 30 m s^{-1}.

(i) Calculate the distance moved by the car during this acceleration.

distance = ... m [2]

(ii) The same force is used to change the speed of the car from 30 m s^{-1} to 45 m s^{-1}. Explain why the distance moved is not the same as that calculated in **(i)**.

....

....

....[1]

Q37.

Use

1 **(a)** Distinguish between scalars and vectors.

....

.... [1]

(b) Underline **all** the vector quantities in the list below.

acceleration kinetic energy momentum power weight [2]

(c) A force of 7.5 N acts at 40° to the horizontal, as shown in Fig. 1.1.

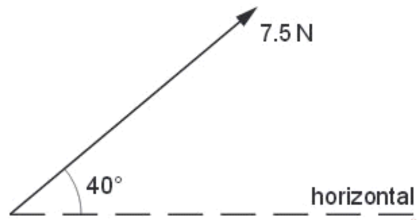


Fig. 1.1

Calculate the component of the force that acts

(i) horizontally,

horizontal component = ... N [1]

(ii) vertically.

vertical component = ... N [1]

(d) Two strings support a load of weight 7.5 N, as shown in Fig. 1.2.

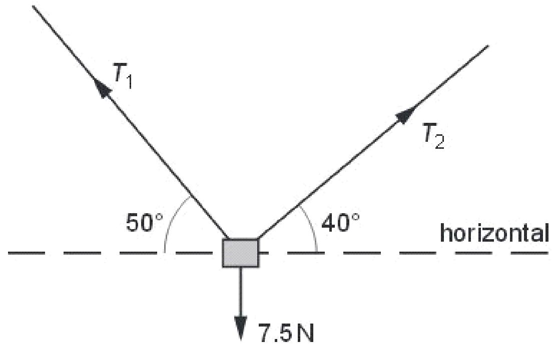


Fig. 1.2

One string has a tension T_1 and is at an angle 50° to the horizontal. The other string has a tension T_2 and is at an angle 40° to the horizontal. The object is in equilibrium. Determine the values of T_1 and T_2 by using a vector triangle or by resolving forces.

T_1 = ... N

T_2 = ... N
[4]

Q38.

1 (a) (i) Define *acceleration*.

....

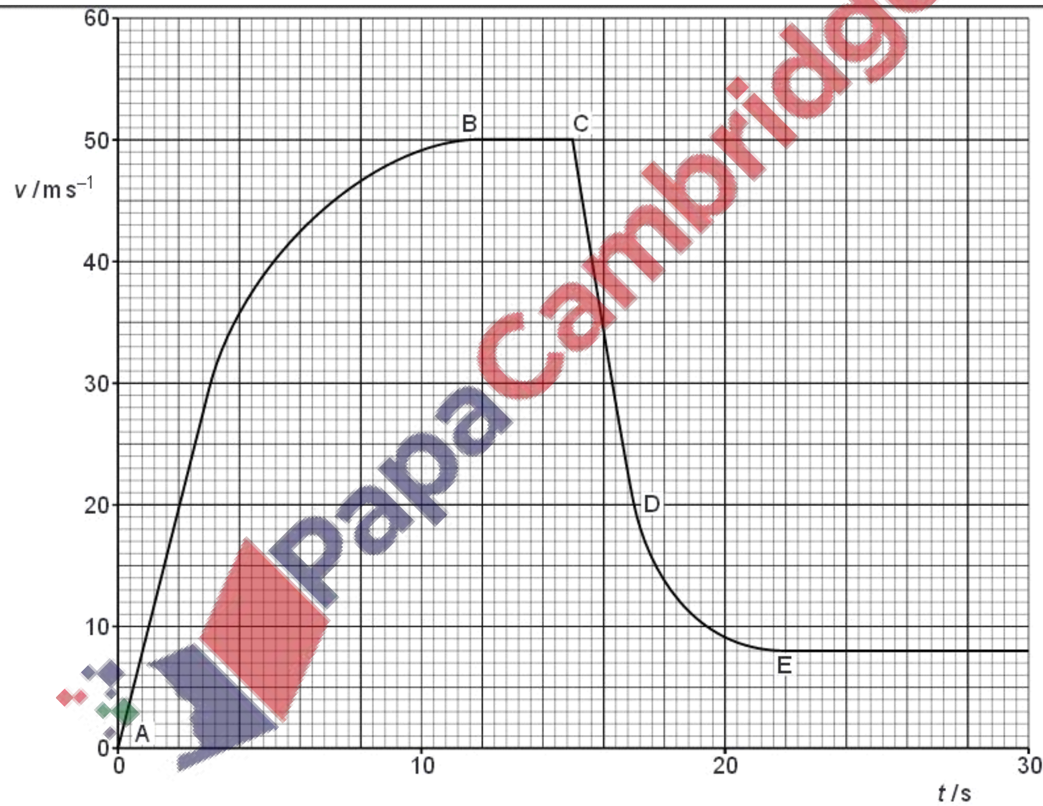
.... [1]

(ii) State Newton's first law of motion.

....

.... [1]

(b) The variation with time t of vertical speed v of a parachutist falling from an aircraft is shown in Fig. 1.1.



(i) Calculate the distance travelled by the parachutist in the first 3.0 s of the motion.

For Examiner's Use

distance = ... m [2]

(ii) Explain the variation of the resultant force acting on the parachutist from t = 0 (point A) to t = 15 s (point C).

....

....

....

....

.... [3]

(iii) Describe the changes to the frictional force on the parachutist

1. at t = 15 s (point C),

....

....

.... [1]

2. between t = 15 s (point C) and t = 22 s (point E).

....

....

.... [1]

(iv) The mass of the parachutist is 95 kg.

Calculate, for the parachutist between t = 15 s (point C) and t = 17 s (point D),

1. the average acceleration,

acceleration = ... m s^{-2} [2]

2. the average frictional force.

frictional force = ... N [3]

Q39.

2 **(a)** State Newton's second law.

....

....[1]

(b) A ball of mass 65 g hits a wall with a velocity of 5.2 m s^{-1} perpendicular to the wall. The ball rebounds perpendicularly from the wall with a speed of 3.7 m s^{-1}. The contact time of the ball with the wall is 7.5 ms.

Calculate, for the ball hitting the wall,

(i) the change in momentum,

change in momentum = ... N s [2]

(ii) the magnitude of the average force.

force = ... N [1]

(c) (i) For the collision in **(b)** between the ball and the wall, state how the following apply:

1. Newton's third law,

....

....

....

....[2]

2. the law of conservation of momentum.

....

....[1]

(ii) State, with a reason, whether the collision is elastic or inelastic.

....

....[1]

Q40.

2 Two planks of wood AB and BC are inclined at an angle of 15° to the horizontal. The two wooden planks are joined at point B, as shown in Fig. 2.1.

For Examiner's Use

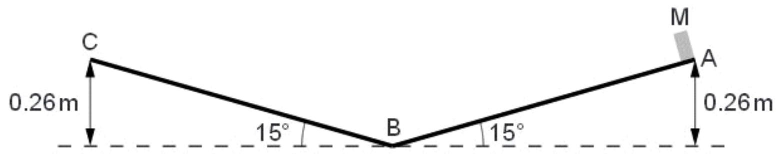


Fig. 2.1

A small block of metal M is released from rest at point A. It slides down the slope to B and up the opposite side to C. Points A and C are 0.26m above B. Assume frictional forces are negligible.

(a) **(i)** Describe and explain the acceleration of M as it travels from A to B and from B to C.

....

....

....

.... [3]

(ii) Calculate the time taken for M to travel from A to B.

time = ... s [3]

(iii) Calculate the speed of M at B.

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

(b) The plank BC is adjusted so that the angle it makes with the horizontal is 30°. M is released from rest at point A and slides down the slope to B. It then slides a distance along the plank from B towards C.

Use the law of conservation of energy to calculate this distance. Explain your working.

distance = ... m [2]

Q41.

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

....

....[2]

(b) A wheel is supported by a pin P at its centre of gravity, as shown in Fig. 4.1.

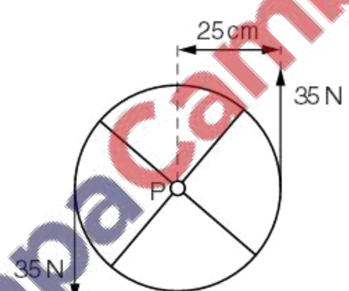


Fig. 4.1

The plane of the wheel is vertical. The wheel has radius 25 cm.
Two parallel forces each of 35 N act on the edge of the wheel in the vertical directions shown in Fig. 4.1. Friction between the pin and the wheel is negligible.

(i) List two other forces that act on the wheel. State the direction of these forces and where they act.

1. ....

2. ....
[2]

(ii) Calculate the torque of the couple acting on the wheel.

torque = ... Nm [2]

(iii) The resultant force on the wheel is zero. Explain, by reference to the four forces acting on the wheel, how it is possible that the resultant force is zero.

....

....[1]

(iv) State and explain whether the wheel is in equilibrium.

....[1]