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Mob: +974 55249797 / 55258711
E-mail:rashed.saba@gmail.com

Accelerated motion: 2

TOPIC- v-t graph, acceleration, gravity, projectiles

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

1 The variation with time t of the displacement s for a car is shown in Fig. 1.1.

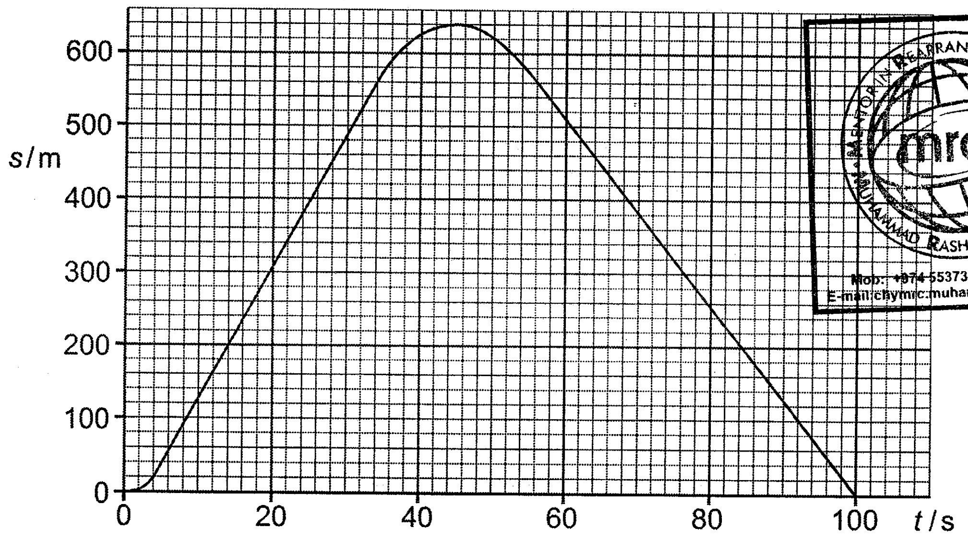

Fig. 1.1

(a) Determine the magnitude of the average velocity between the times 5.0 s and 35.0 s.

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

(b) On Fig. 1.2, sketch the variation with time t of the velocity v for the car.

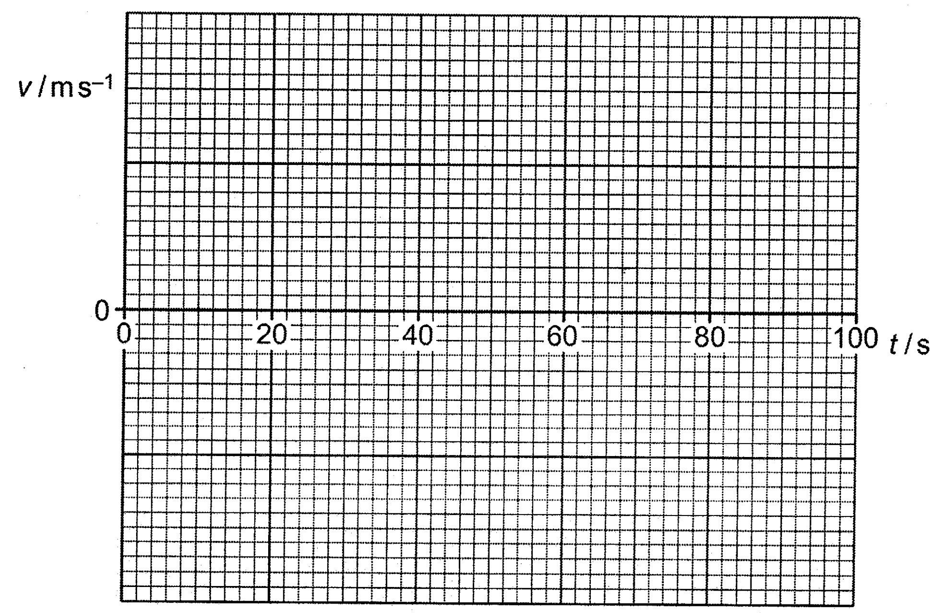

Fig. 1.2

[4]

2 **(a)** Define *acceleration*.

....

.... [1]

(b) A ball is kicked from horizontal ground towards the top of a vertical wall, as shown in Fig. 2.1.

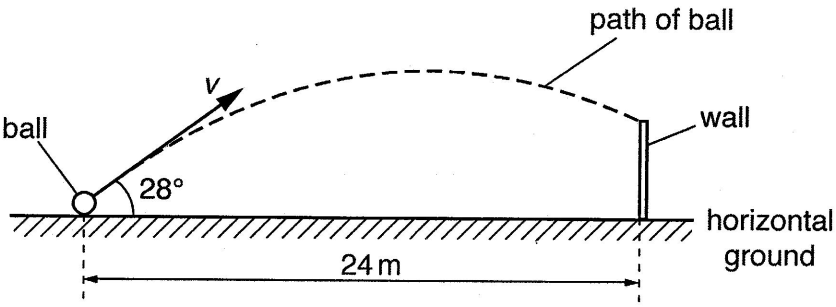

Fig. 2.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance may be assumed to be negligible.

(i) Calculate the initial horizontal component v_X of the velocity of the ball.

v_X = ... $m s^{-1}$ [1]

(ii) Show that the initial vertical component v_Y of the velocity of the ball is $8.5 m s^{-1}$.

[2]

(iii) Calculate the time taken for the ball to reach its maximum height above the ground.

time = ... s [2]

(iv) The ball is kicked at time $t = 0$. On Fig. 2.2, sketch the variation with time t of the vertical component v_Y of the velocity of the ball until it hits the wall. It may be assumed that velocity is positive when in the upwards direction.

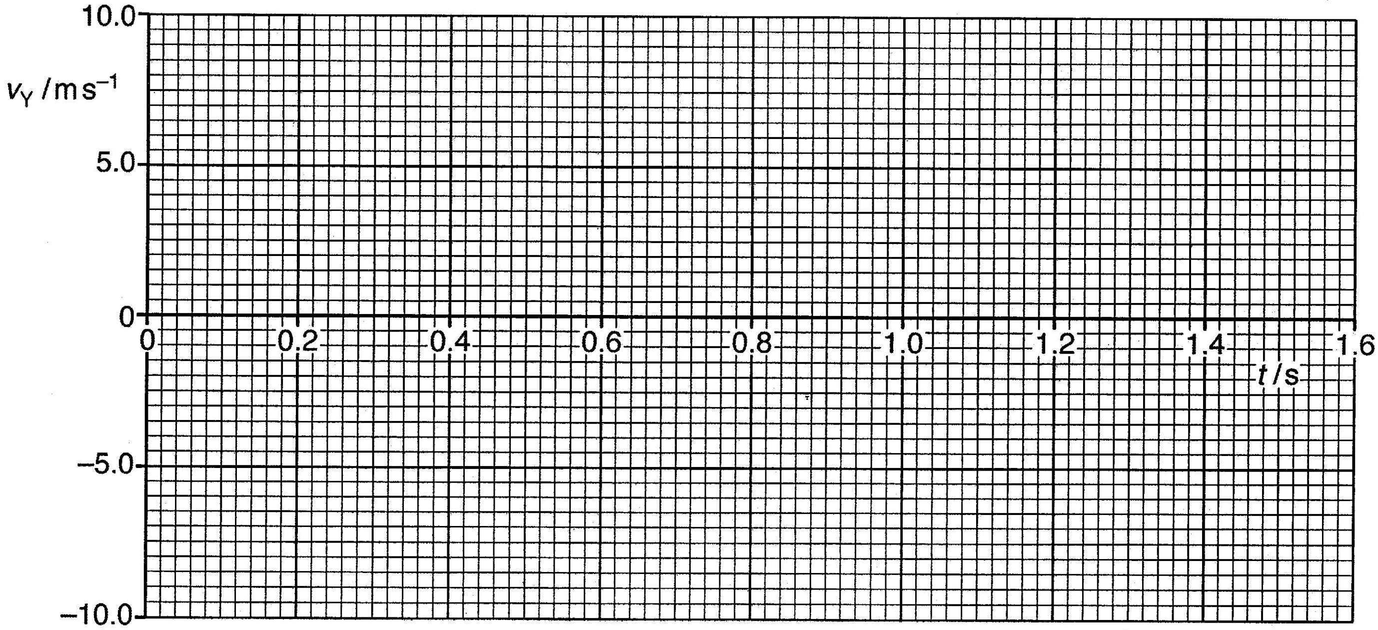

Fig. 2.2

[2]

(c) **(i)** Use the information in **(b)** to determine the maximum height of the ball above the ground.

maximum height = ... m [2]

(ii) The maximum gravitational potential energy of the ball above the ground is 22 J. Calculate the mass of the ball.

mass = ... kg [2]

(d) A ball of greater mass is kicked with the same velocity as the ball in **(b)**.
State and explain the effect, if any, of the increased mass on the maximum height reached by the ball. Air resistance is still assumed to be negligible.

....

.... [1]

[Total: 13]

3 **(a)** An object is moved from point P to point R either by a direct path or by the path P to Q to R, as shown in Fig. 3.1.

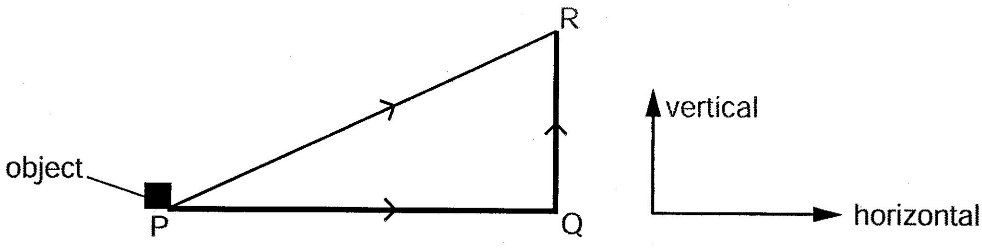

Fig. 3.1

P and Q are on the same horizontal level. R is vertically above Q.

Explain whether the work done moving the object against the gravitational field is the same or different along paths PR and PQR.

....

....

....

.... [2]

(b) A ball is thrown with an initial velocity V at an angle θ to the horizontal, as shown in Fig. 3.2.

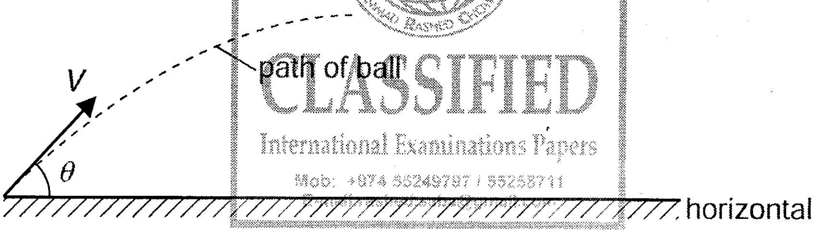

Fig. 3.2 (not to scale)

The variation with time t of the height h of the ball is shown in Fig. 3.3.

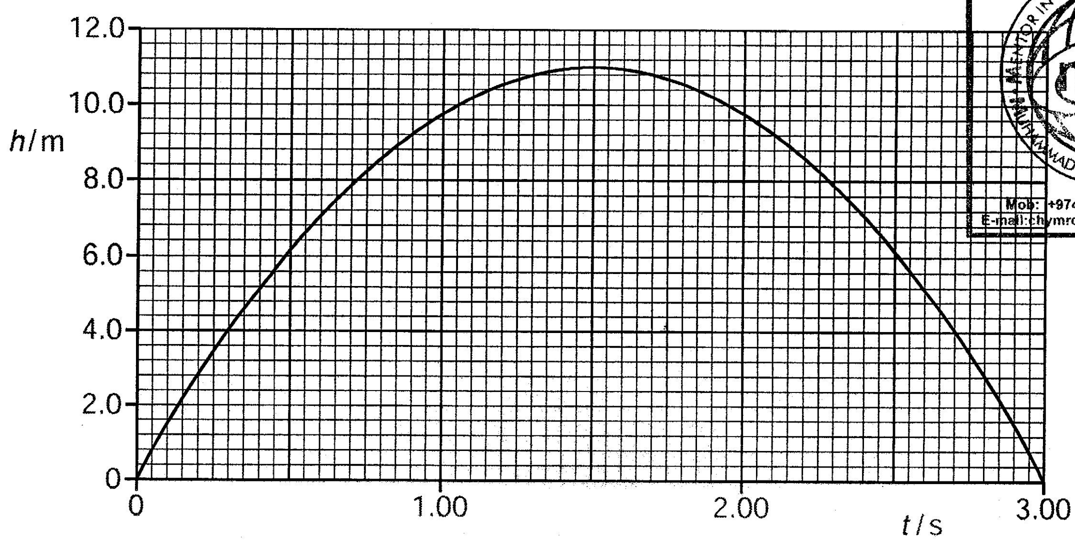

Fig. 3.3

Air resistance is negligible.

(i) Use the time to reach maximum height to determine the vertical component V_v of the velocity of the ball for time $t = 0$.

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

(ii) The horizontal displacement of the ball at $t = 3.00$ s is 25.5 m.
On Fig. 3.4, draw the variation with t of the horizontal displacement x of the ball.

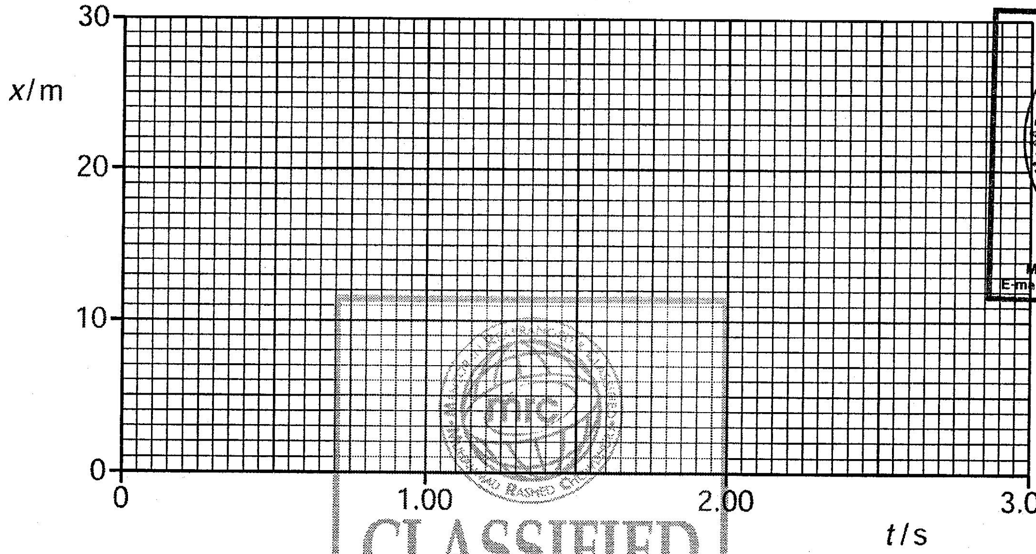

Fig. 3.4

[1]

(iii) For the ball at maximum height, calculate the ratio

$$\frac{\text{potential energy of the ball}}{\text{kinetic energy of the ball}}.$$

ratio = ... [3]

(iv) In practice, air resistance is not negligible. State and explain the effect of air resistance on the time taken for the ball to reach maximum height.

....

....

....

....[2]

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

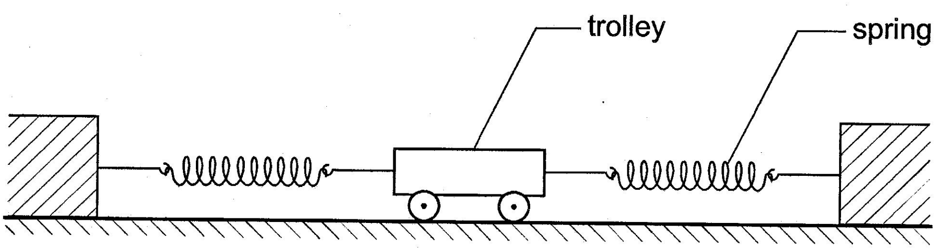

Fig. 4.1

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.

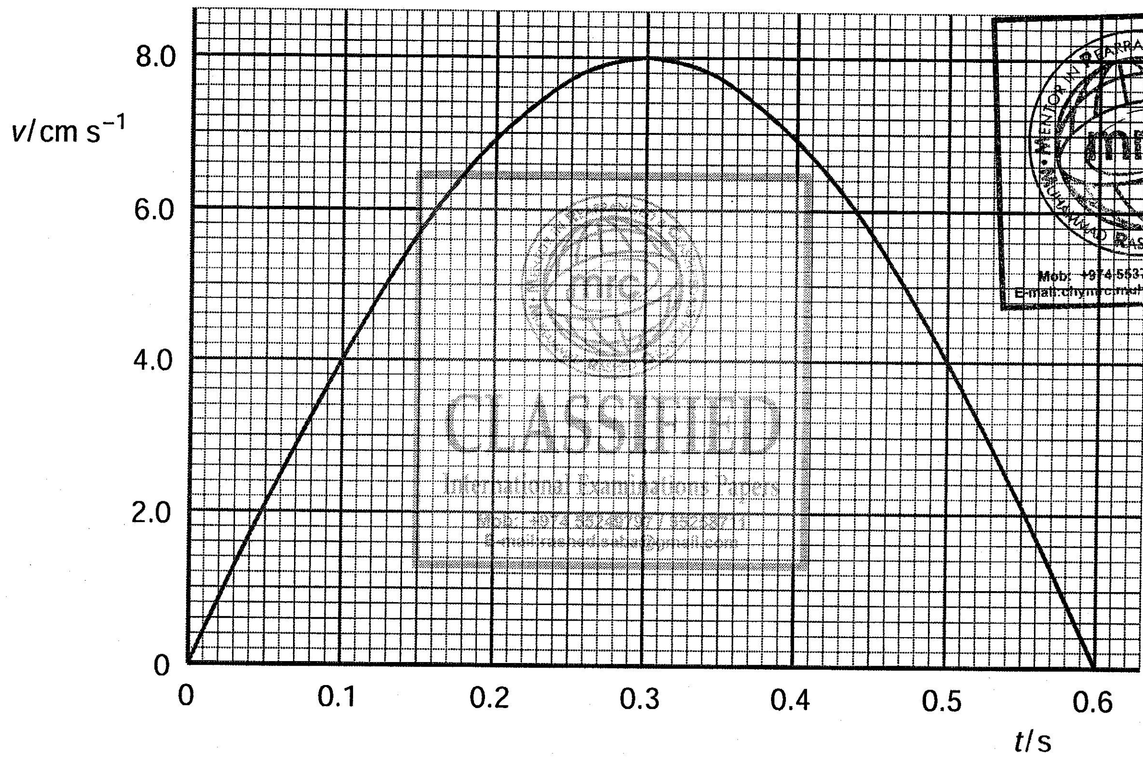

Fig. 4.2

(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.

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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]

5 **(a)** A sphere of radius R is moving through a fluid with constant speed v. There is a frictional force F acting on the sphere, which is given by the expression

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$$F = 6\pi DRv$$

where D depends on the fluid.

(i) Show that the SI base units of the quantity D are $kg\,m^{-1}\,s^{-1}$.

[3]

(ii) A raindrop of radius 1.5 mm falls vertically in air at a velocity of $3.7\,m\,s^{-1}$. The value of D for air is $6.6 \times 10^{-4}\,kg\,m^{-1}\,s^{-1}$. The density of water is $1000\,kg\,m^{-3}$.

Calculate

1. the magnitude of the frictional force F,

F = ... N [1]

2. the acceleration of the raindrop.

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

(b) The variation with time t of the speed v of the raindrop in **(a)** is shown in Fig. 2.1.

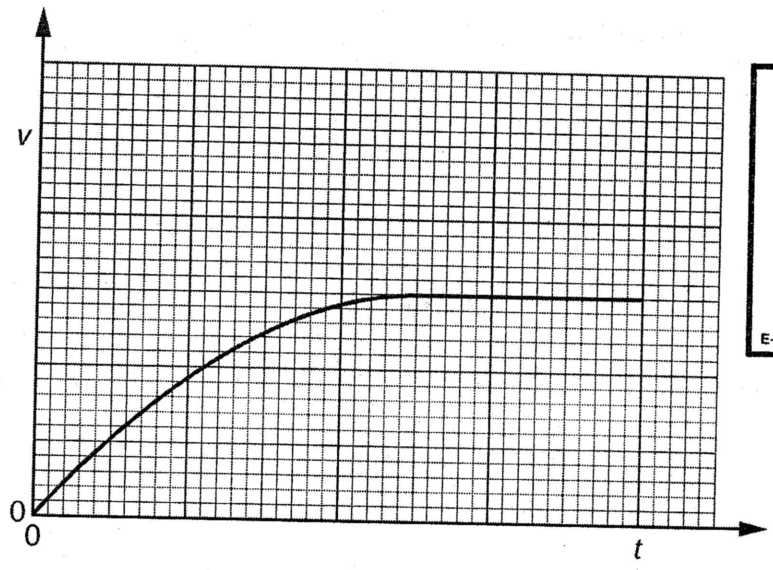

Fig. 2.1

(i) State the variation with time of the **acceleration** of the raindrop.

....

....

....

....

.... [3]

(ii) A second raindrop has a radius that is smaller than that given in **(a)**. On Fig. 2.1, sketch the variation of speed with time for this second raindrop. [2]

06 (a) A student walks from A to B along the path shown in Fig. 2.1.

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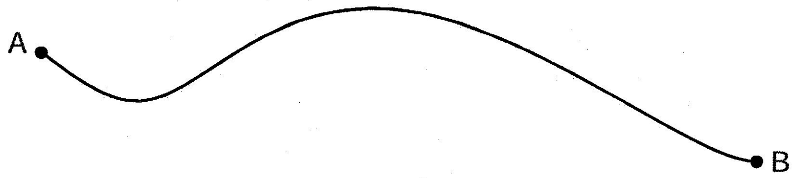

Fig. 2.1

The student takes time *t* to walk from A to B.

(i) State the quantity, apart from *t*, that must be measured in order to determine the average value of

1. speed,

....

.... [1]

2. velocity.

....

.... [1]

(ii) Define *acceleration*.

.... [1]

(b) A girl falls vertically onto a trampoline, as shown in Fig. 2.2.

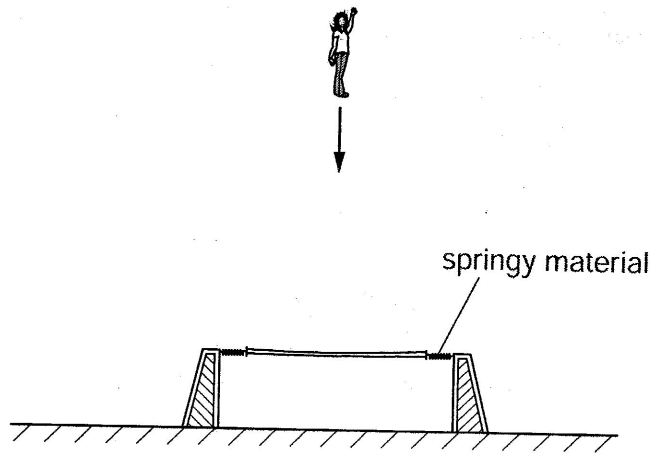

Fig. 2.2

The trampoline consists of a central section supported by springy material. At time t = 0 the girl starts to fall. The girl hits the trampoline and rebounds vertically. The variation with time t of velocity v of the girl is illustrated in Fig. 2.3.

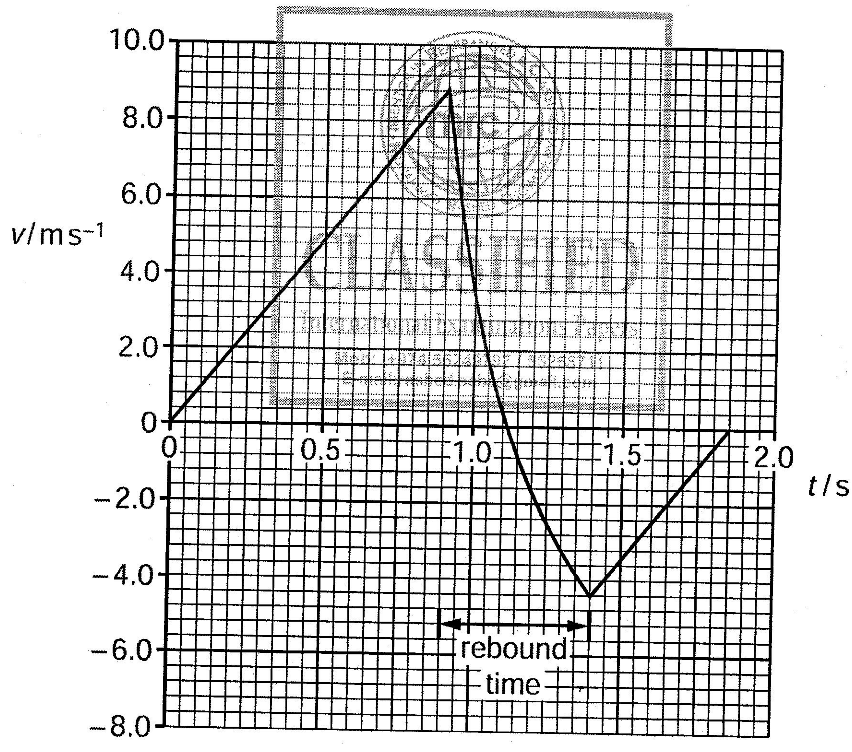

Fig. 2.3

For the motion of the girl, calculate

(i) the distance fallen between time t = 0 and when she hits the trampoline,

distance = ... m [2]

For Examiner's Use

(ii) the average acceleration during the rebound.

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

(c) **(i)** Use Fig. 2.3 to compare, without calculation, the accelerations of the girl before and after the rebound. Explain your answer.

....

....

....[2]

(ii) Use Fig. 2.3 to compare, without calculation, the potential energy of the girl at $t = 0$ and $t = 1.85$ s. Explain your answer.

....

....

....[2]

0 7 (a) Define *force*.

.... [1]

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(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.

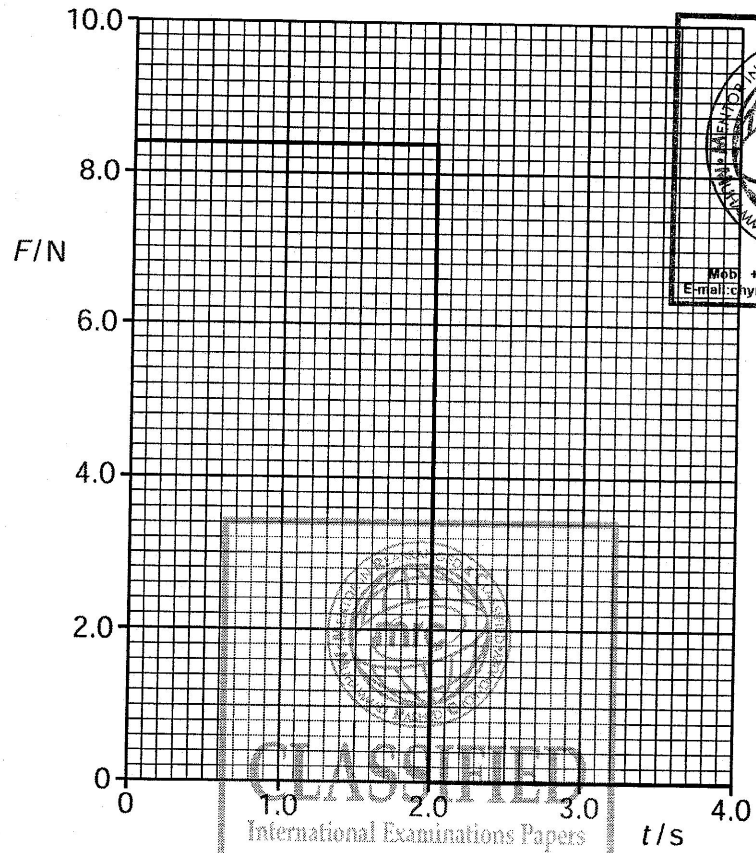

Fig. 2.1

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.

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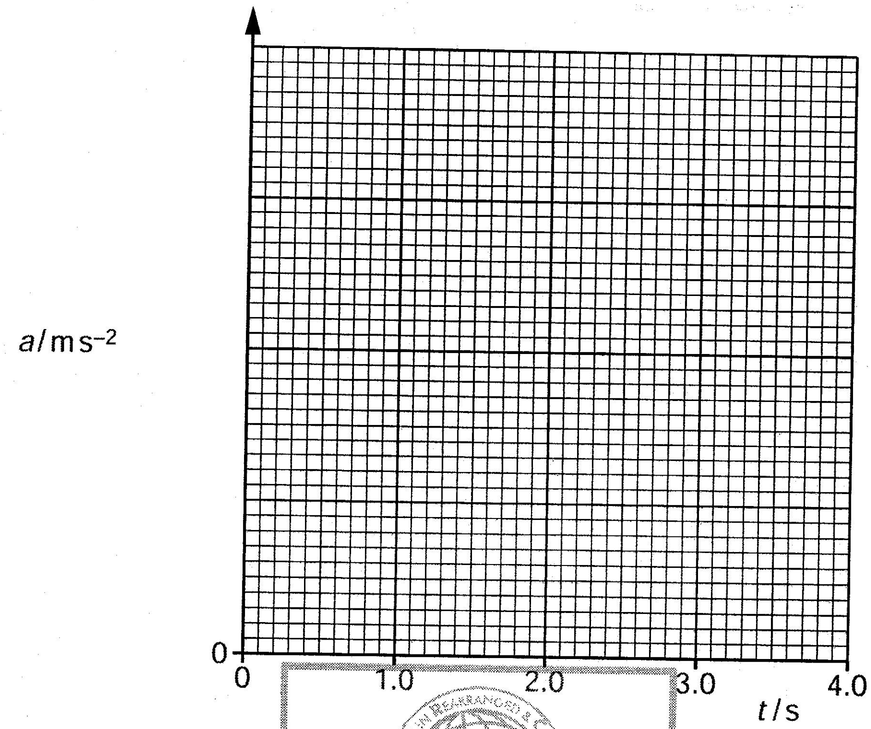

Fig. 2.2

[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.

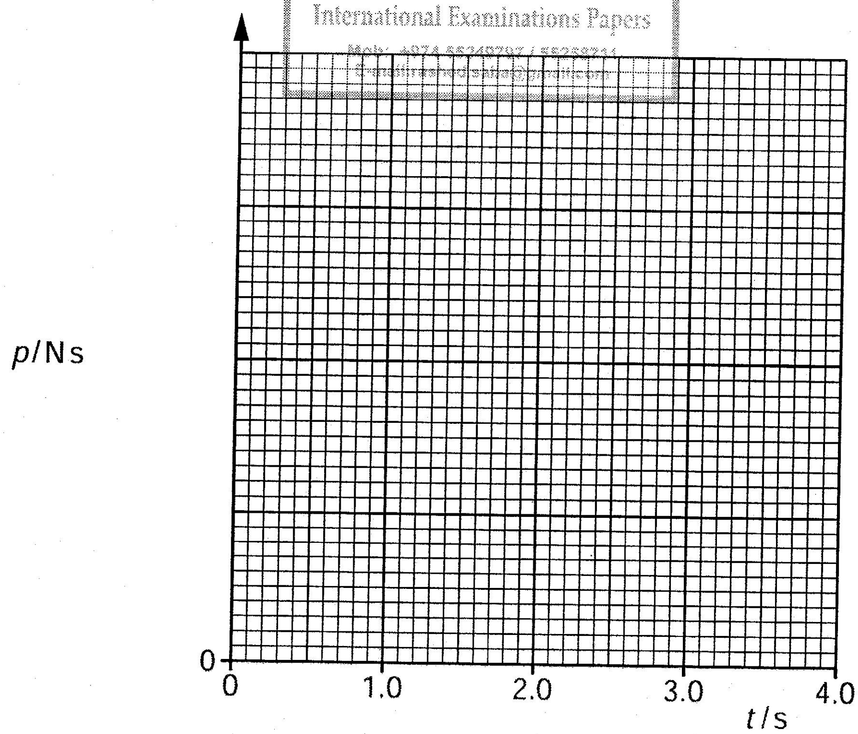

Fig. 2.3

[5]

08 A stone is thrown vertically upwards. The variation with time t of the displacement s of the stone is shown in Fig. 2.1.

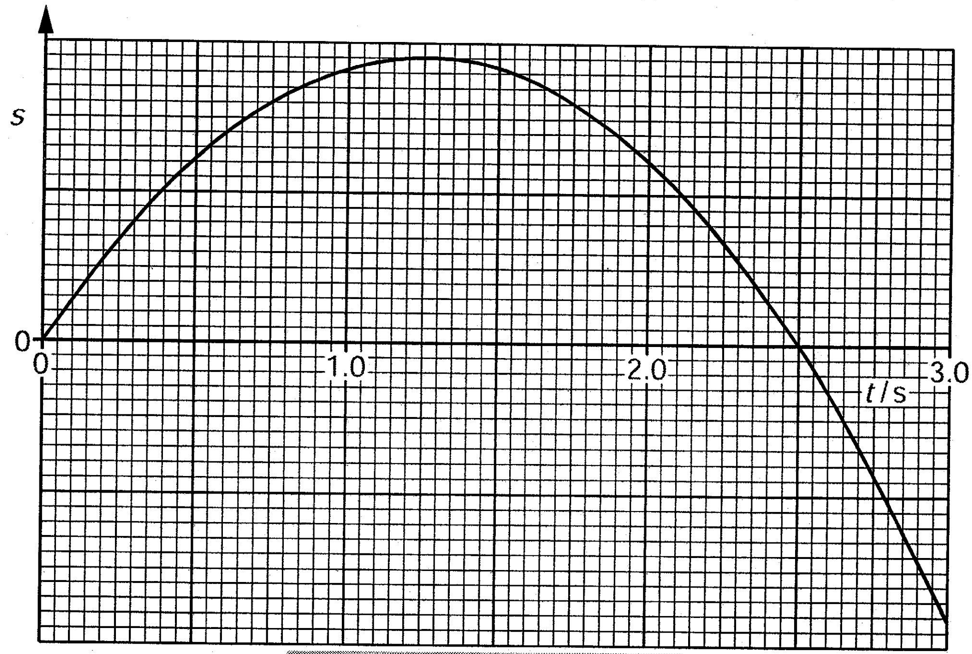

Fig. 2.1

(a) Use Fig. 2.1 to describe, without calculation, the speed of the stone from $t = 0$ to $t = 3.0$ s.

....

....

.... [2]

(b) Assume air resistance is negligible and therefore the stone has constant acceleration.

Calculate, for the stone,

(i) the speed at 3.0 s,

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

(ii) the distance travelled from $t = 0$ to $t = 3.0\,\text{s}$,

distance = ... m [3]

(iii) the displacement from $t = 0$ to $t = 3.0\,\text{s}$.

displacement = ... m

direction ....

[2]

(c) On Fig. 2.2, draw the variation with time t of the velocity v of the stone from $t = 0$ to $t = 3.0\,\text{s}$.

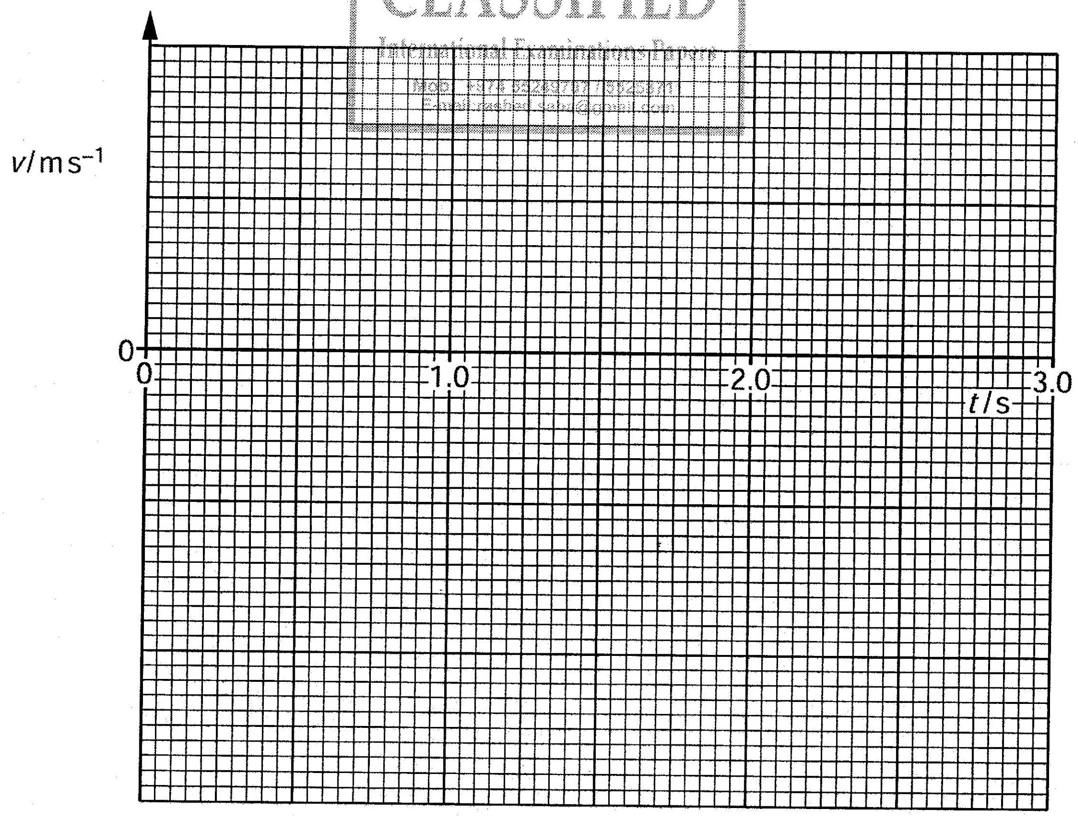

Fig. 2.2

[3]

09 **(a)** Define *speed* and *velocity* and use these definitions to explain why one of these quantities is a scalar and the other is a vector.

speed: ....

velocity: ....

....

....

[2]

(b) A ball is released from rest and falls vertically. The ball hits the ground and rebounds vertically, as shown in Fig. 2.1.

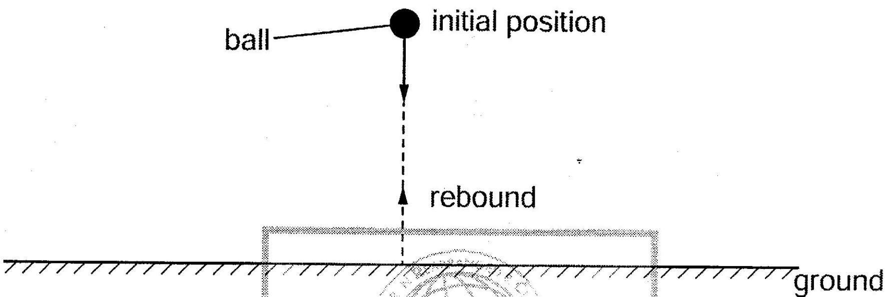

Fig. 2.1

The variation with time t of the velocity v of the ball is shown in Fig. 2.2.

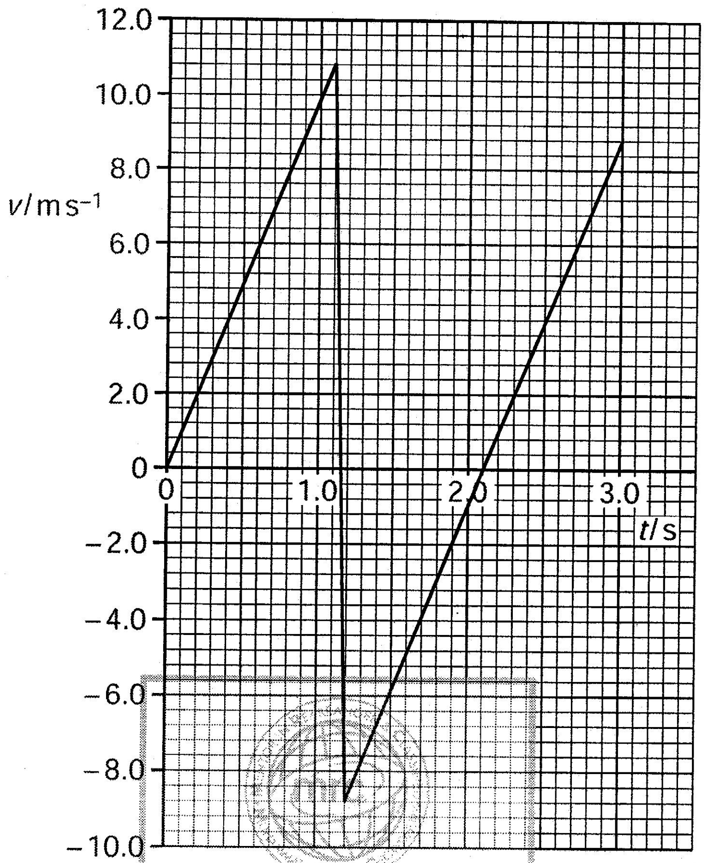

Fig. 2.2

Air resistance is negligible.

(i) Without calculation, use Fig. 2.2 to describe the variation with time t of the velocity of the ball from $t = 0$ to $t = 2.1$ s.

....

....

....

....

....

....[3]

(ii) Calculate the acceleration of the ball after it rebounds from the ground. Show your working.

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

(iii) Calculate, for the ball, from $t = 0$ to $t = 2.1$ s,

1. the distance moved,

distance = ... m [3]

2. the displacement from the initial position.

displacement = ... m [2]

(iv) On Fig. 2.3, sketch the variation with t of the speed of the ball.

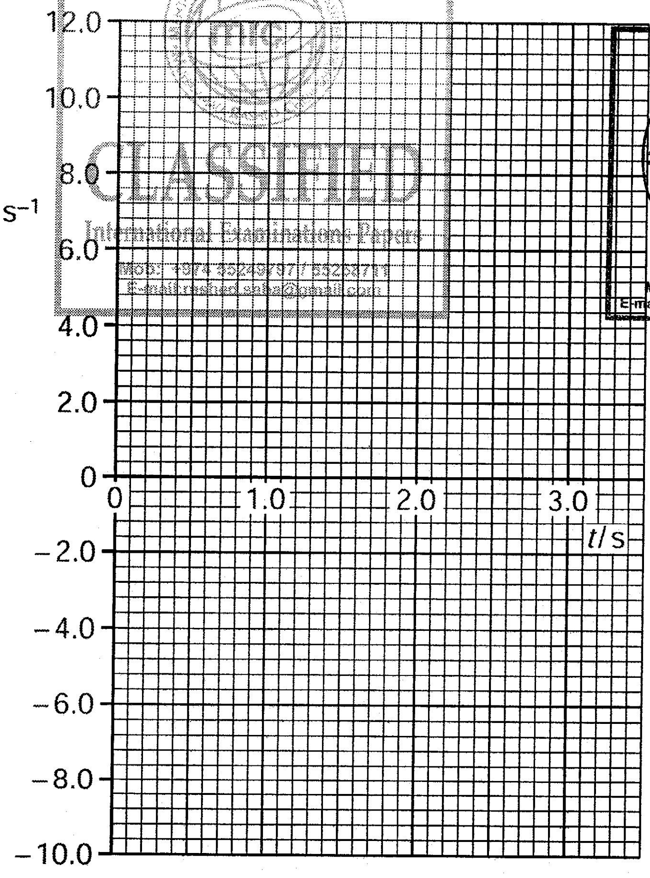

Fig. 2.3

[2]

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

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

....

.... [1]

(ii) Distinguish between *speed* and *velocity*.

....

.... [2]

(b) A car of mass 1500 kg moves along a straight, horizontal road. The variation with time t of the velocity v for the car is shown in Fig. 1.1.

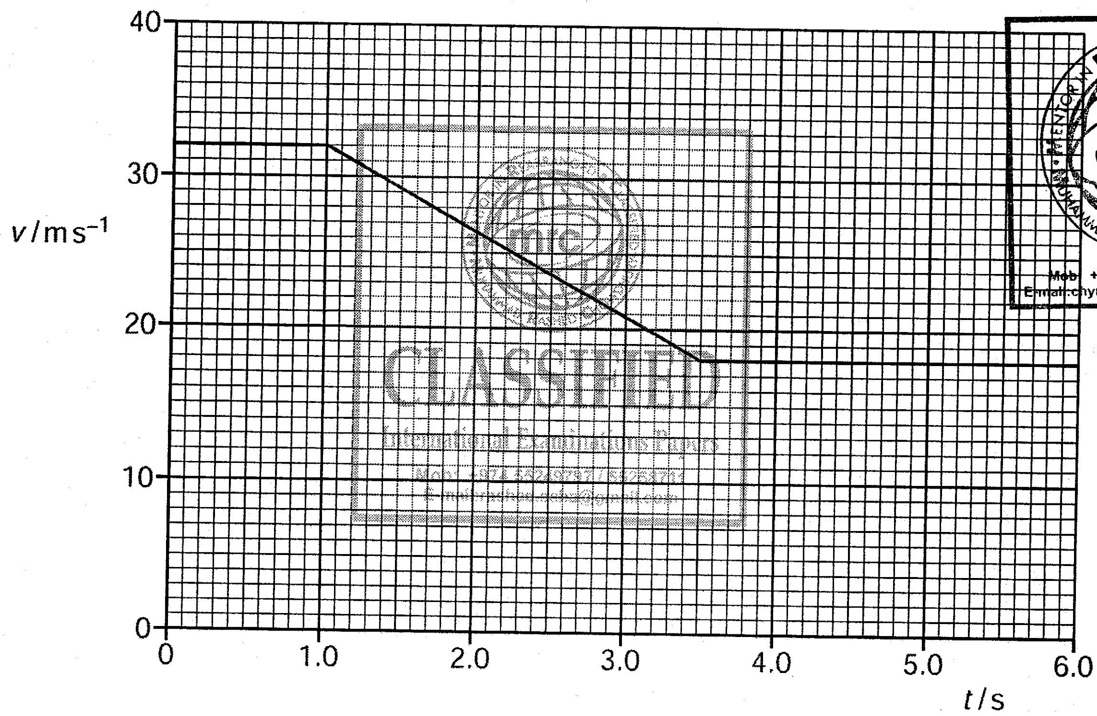

Fig. 1.1

The brakes of the car are applied from t = 1.0 s to t = 3.5 s.
For the time when the brakes are applied,

(i) calculate the distance moved by the car,

distance = ... m [3]

(ii) calculate the magnitude of the resultant force on the car.

resultant force = ... N [3]

(c) The direction of motion of the car in **(b)** at time t = 2.0 s is shown in Fig. 1.2.

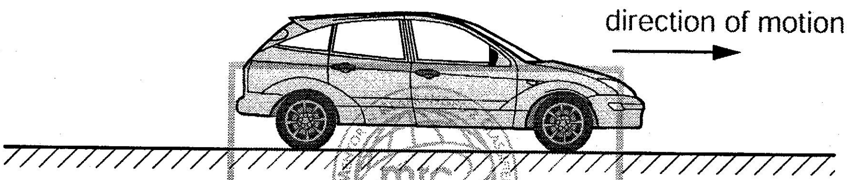

Fig. 1.2

On Fig. 1.2, show with arrows the directions of the acceleration (label this arrow A) and the resultant force (label this arrow F). [1]

1 A ball is thrown from a point P with an initial velocity u of 12 m s^{-1} at 50° to the horizontal, as illustrated in Fig. 2.1.

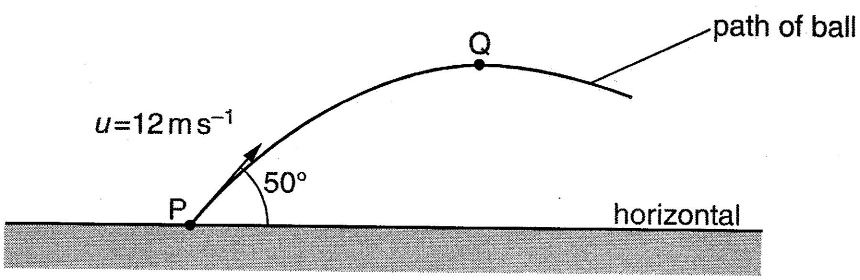

Fig. 2.1

The ball reaches maximum height at Q.

Air resistance is negligible.

(a) Calculate

(i) the horizontal component of u,

horizontal component = ... m s^{-1} [1]

(ii) the vertical component of u.

vertical component = ... m s^{-1} [1]

(b) Show that the maximum height reached by the ball is 4.3 m.

[2]

(c) Determine the magnitude of the displacement PQ.

displacement = ... m [4]

[Total: 8]

12 **(a)** Explain what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: ....

....

vector: ....

....

[2]

(b) A ball leaves point P at the top of a cliff with a horizontal velocity of 15 m s^{-1}, as shown in Fig. 2.1.

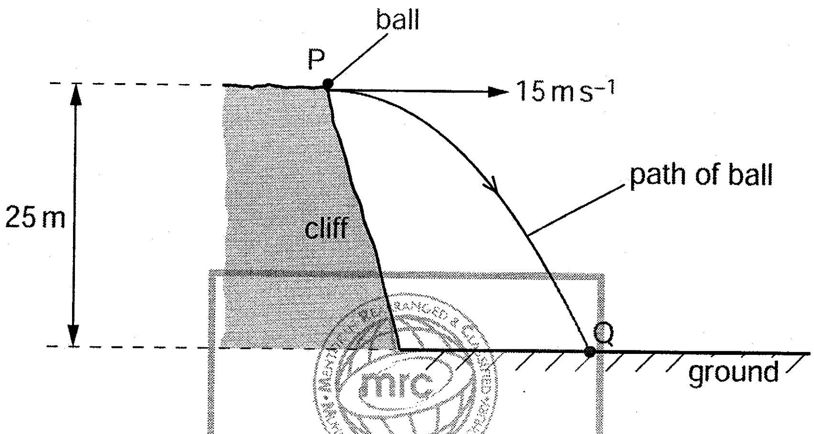

Fig. 2.1

The height of the cliff is 25 m. The ball hits the ground at point Q.
Air resistance is negligible.

(i) Calculate the vertical velocity of the ball just before it makes impact with the ground at Q.

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

(ii) Show that the time taken for the ball to fall to the ground is 2.3 s.

[1]

(iii) Calculate the magnitude of the displacement of the ball at point Q from point P.

displacement = ... m [4]

(iv) Explain why the distance travelled by the ball is different from the magnitude of the displacement of the ball.

....

....

.... [2]

13 A ball is thrown against a vertical wall. The path of the ball is shown in Fig. 3.1.

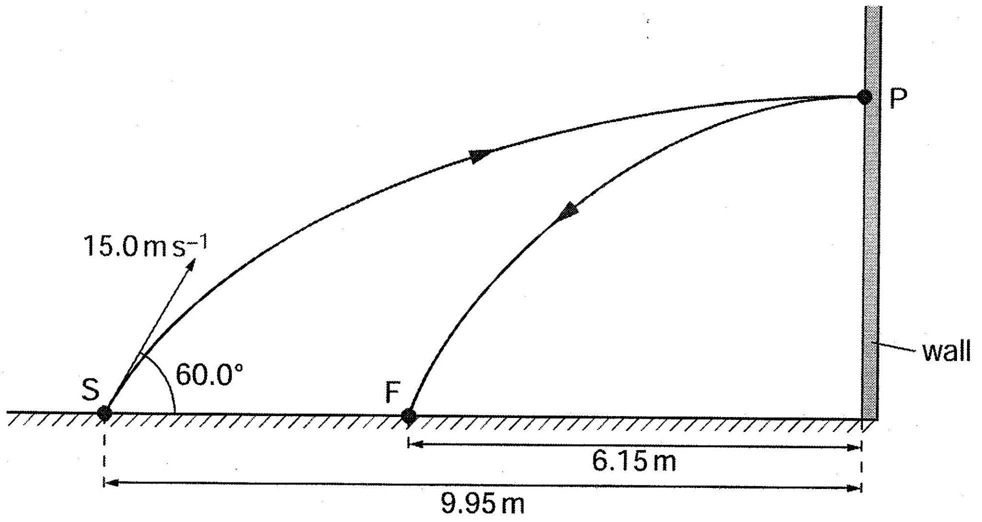

Fig. 3.1 (not to scale)

The ball is thrown from S with an initial velocity of 15.0 m s^{-1} at 60.0° to the horizontal. Assume that air resistance is negligible.

(a) For the ball at S, calculate

(i) its horizontal component of velocity,

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

(ii) its vertical component of velocity.

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

(b) The horizontal distance from S to the wall is 9.95 m. The ball hits the wall at P with a velocity that is at right angles to the wall. The ball rebounds to a point F that is 6.15 m from the wall.

Using your answers in **(a)**,

(i) calculate the vertical height gained by the ball when it travels from S to P,

height = ... m [1]

(ii) show that the time taken for the ball to travel from S to P is 1.33 s,

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[1]

(iii) show that the velocity of the ball immediately after rebounding from the wall is about 4.6 m s^{-1}.

[1]

(c) The mass of the ball is 60×10^{-3} kg.

(i) Calculate the change in momentum of the ball as it rebounds from the wall.

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

(ii) State and explain whether the collision is elastic or inelastic.

....

....

.... [1]

14 A ball is thrown from a point P, which is at ground level, as illustrated in Fig. 2.1.

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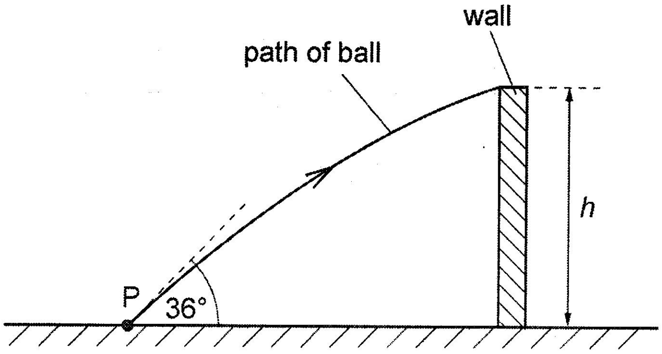

Fig. 2.1

The initial velocity of the ball is $12.4\,\text{m}\,\text{s}^{-1}$ at an angle of 36° to the horizontal.
The ball just passes over a wall of height h. The ball reaches the wall 0.17 s after it has been thrown.

(a) Assuming air resistance to be negligible, calculate

(i) the horizontal distance of point P from the wall,

distance = ... m [2]

(ii) the height h of the wall.

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h = ... m [3]

(b) A second ball is thrown from point P with the same velocity as the ball in **(a)**. For this ball, air resistance is not negligible.
This ball hits the wall and rebounds.

On Fig. 2.1, sketch the path of this ball between point P and the point where it first hits the ground. [2]

15 A ball is thrown horizontally from the top of a building, as shown in Fig. 2.1.

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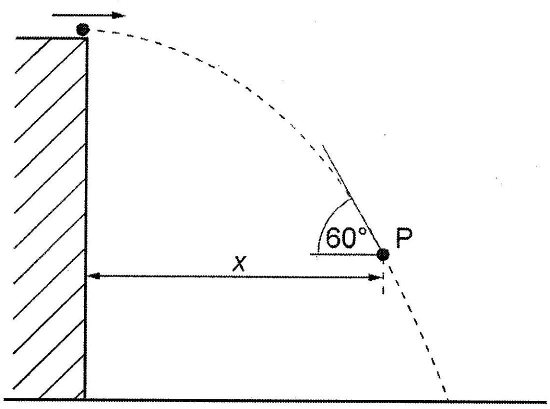

Fig. 2.1

The ball is thrown with a horizontal speed of $8.2\,\text{m s}^{-1}$. The side of the building is vertical. At point P on the path of the ball, the ball is distance x from the building and is moving at an angle of 60° to the horizontal. Air resistance is negligible.

(a) For the ball at point P,

(i) show that the vertical component of its velocity is $14.2\,\text{m s}^{-1}$,

[2]

(ii) determine the vertical distance through which the ball has fallen,

distance = ... m [2]

(iii) determine the horizontal distance x.

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x = ... m [2]

(b) The path of the ball in **(a)**, with an initial horizontal speed of $8.2\,m\,s^{-1}$, is shown again in Fig. 2.2.

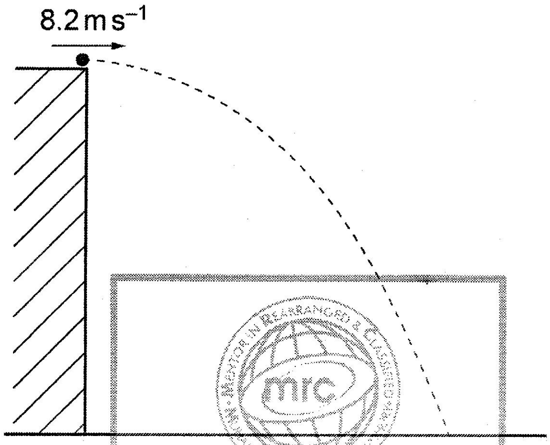

Fig. 2.2

On Fig. 2.2, sketch the new path of the ball for the ball having an initial horizontal speed

(i) greater than $8.2\,m\,s^{-1}$ and with negligible air resistance (label this path G), [2]

(ii) equal to $8.2\,m\,s^{-1}$ but with air resistance (label this path A). [2]

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

For Examiner's Use

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.

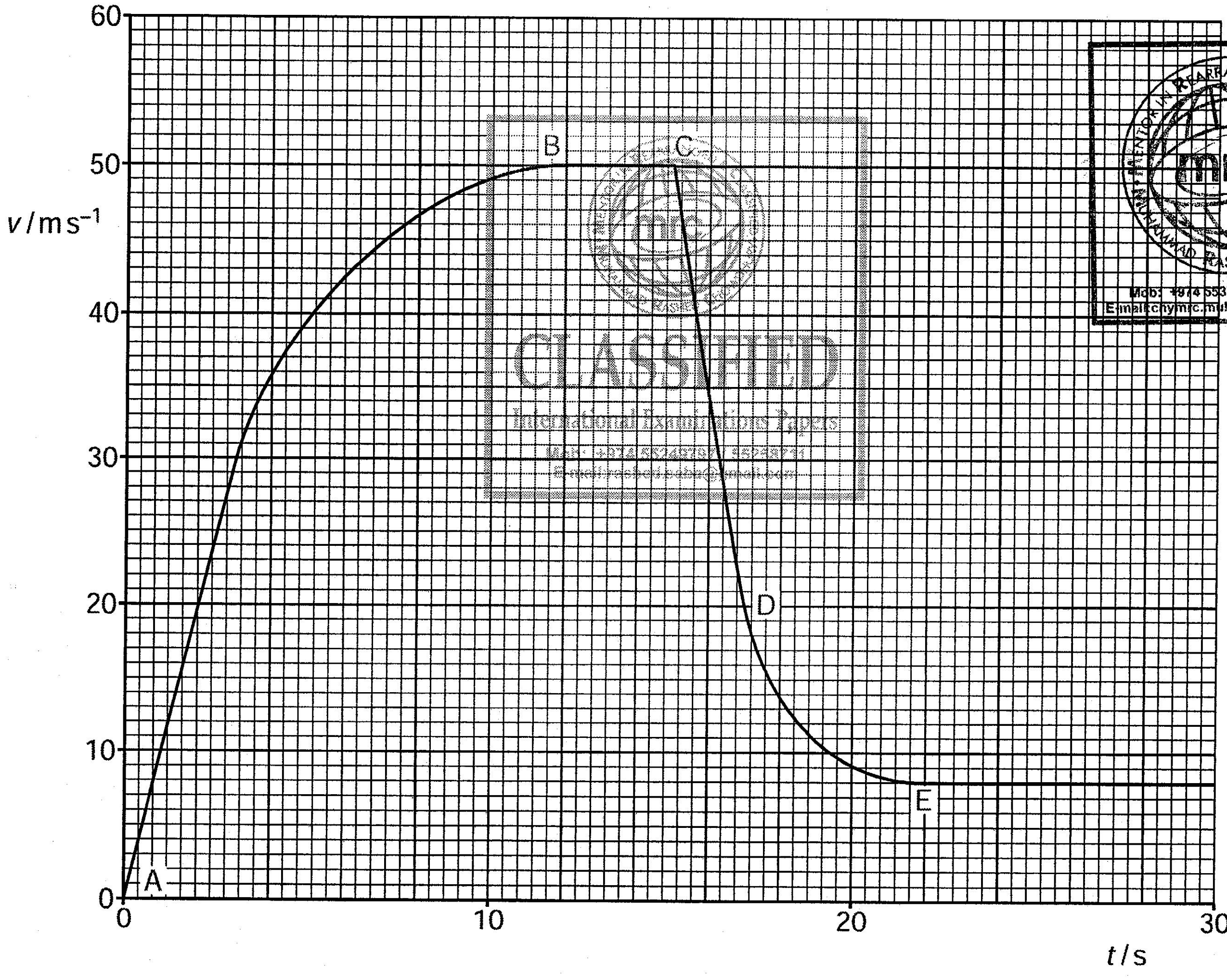

Fig. 1.1

For Examiner's Use

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

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]

For Examiner's Use

1 7 A trolley moves down a slope, as shown in Fig. 4.1.

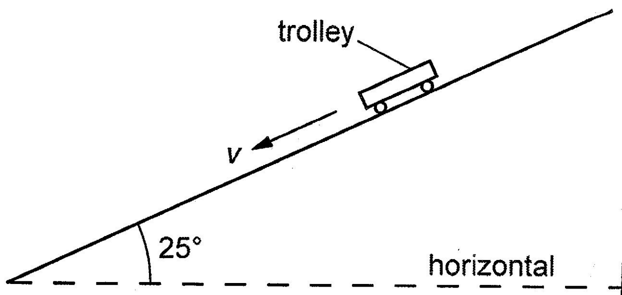

Fig. 4.1

The slope makes an angle of 25° with the horizontal. A constant resistive force F_R acts up the slope on the trolley.
At time $t = 0$, the trolley has velocity $v = 0.50\,\text{m}\,\text{s}^{-1}$ down the slope.
At time $t = 4.0\,\text{s}$, $v = 12\,\text{m}\,\text{s}^{-1}$ down the slope.

(a) **(i)** Show that the acceleration of the trolley down the slope is approximately $3\,\text{m}\,\text{s}^{-2}$.

[2]

(ii) Calculate the distance x moved by the trolley down the slope from time $t = 0$ to $t = 4.0\,\text{s}$.

x = ... m [2]

(iii) On Fig. 4.2, sketch the variation with time t of distance x moved by the trolley.

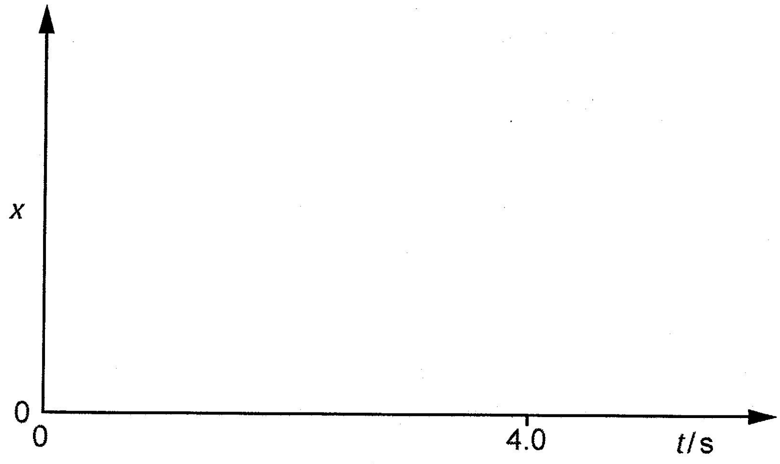

Fig. 4.2

[2]

(b) The mass of the trolley is 2.0 kg.

(i) Show that the component of the weight of the trolley down the slope is 8.3 N.

[1]

(ii) Calculate the resistive force F_R.

F_R = ... N [2]

18 (a) Define *velocity*.

....

....[1]

(b) A car travels in a straight line up a slope, as shown in Fig. 3.1.

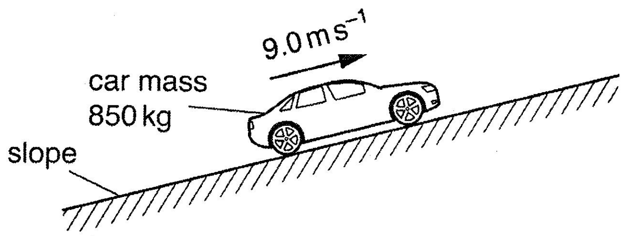

Fig. 3.1

The car has mass 850 kg and travels with a constant speed of $9.0\,\text{m s}^{-1}$. The car's engine exerts a force on the car of 2.0 kN up the slope.

A resistive force F_D, due to friction and air resistance, opposes the motion of the car.

The variation of F_D with the speed v of the car is shown in Fig. 3.2.

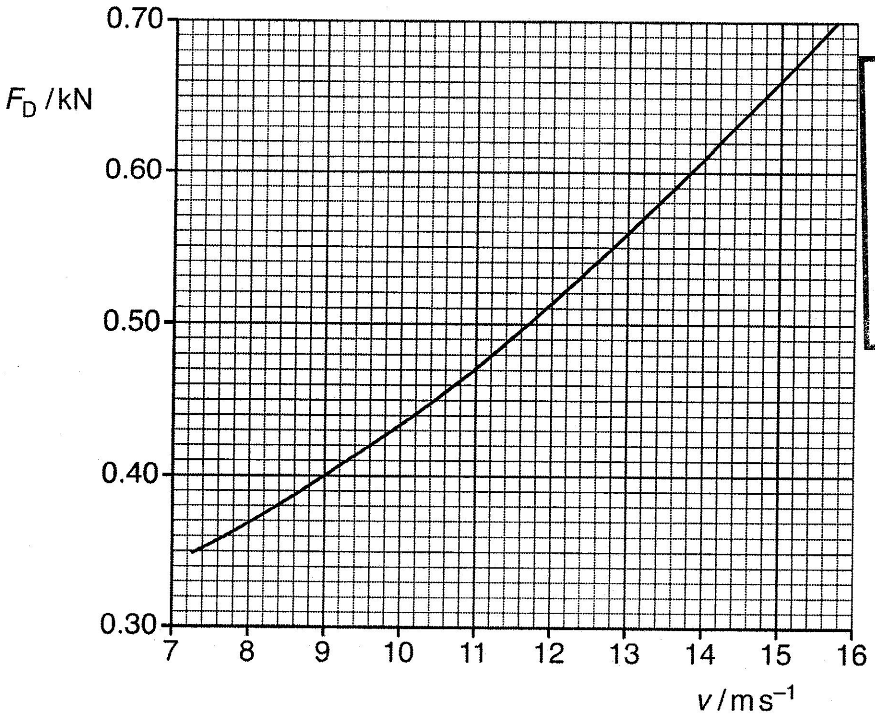

Fig. 3.2

(i) State and explain whether the car is in equilibrium as it moves up the slope.

....

....

....[2]

(ii) Consider the forces that act along the slope. Use data from Fig. 3.2 to determine the component of the weight of the car that acts down the slope.

component of weight = ... N [2]

(iii) Show that the power output of the car is 1.8×10^4 W.

[2]

(iv) The car now travels along horizontal ground. The output power of the car is maintained at 1.8×10^4 W. The variation of the resistive force F_D acting on the car is given in Fig. 3.2.

Calculate the acceleration of the car when its speed is $15\,m\,s^{-1}$.

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

[Total: 10]

19 (a) Define

For Examiner's Use

(i) *velocity*,

....

.... [1]

(ii) *acceleration*.

....

.... [1]

(b) A car of mass 1500 kg travels along a straight horizontal road.
The variation with time *t* of the displacement *x* of the car is shown in Fig. 3.1.

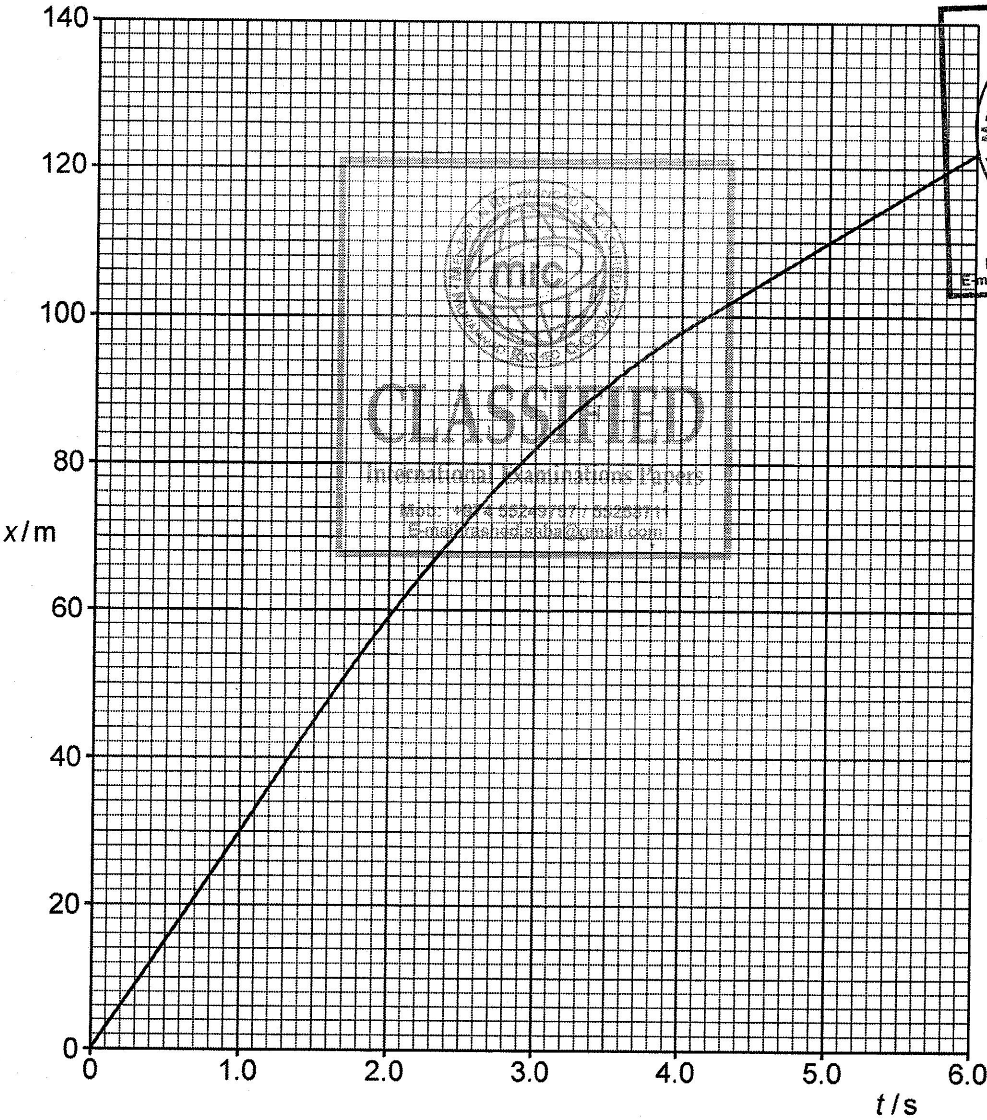

Fig. 3.1

For Examiner's Use

(i) Use Fig. 3.1 to describe qualitatively the velocity of the car during the first six seconds of the motion shown.
Give reasons for your answers.

....

....

....

....

.... [3]

(ii) Calculate the average velocity during the time interval $t = 0$ to $t = 1.5\,\text{s}$.

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

(iii) Show that the average acceleration between $t = 1.5\,\text{s}$ and $t = 4.0\,\text{s}$ is $-7.2\,\text{m s}^{-2}$.

[2]

(iv) Calculate the average force acting on the car between $t = 1.5\,\text{s}$ and $t = 4.0\,\text{s}$.

force = ... N [2]

20 **(a)** Define *power*.

....

.... [1]

(b) A cyclist travels along a horizontal road. The variation with time t of speed v is shown in Fig. 3.1.

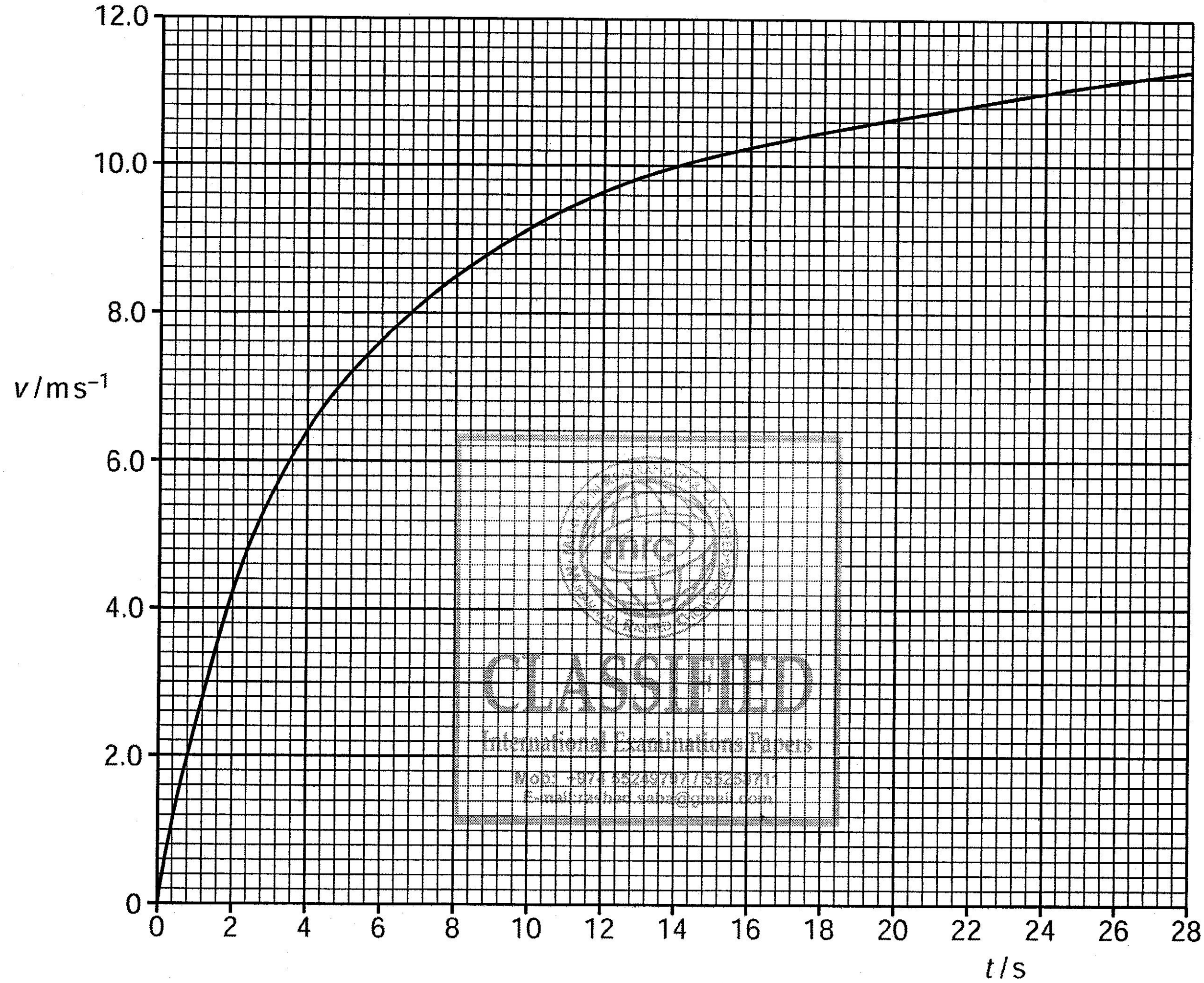

Fig. 3.1

The cyclist maintains a constant power and after some time reaches a constant speed of $12\,m\,s^{-1}$.

(i) Describe and explain the motion of the cyclist.

....

....

....

....

.... [3]

(ii) When the cyclist is moving at a constant speed of $12\,m\,s^{-1}$ the resistive force is 48 N. Show that the power of the cyclist is about 600 W. Explain your working.

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[2]

(iii) Use Fig. 3.1 to show that the acceleration of the cyclist when his speed is $8.0\,m\,s^{-1}$ is about $0.5\,m\,s^{-2}$.

[2]

(iv) The total mass of the cyclist and bicycle is 80 kg. Calculate the resistive force *R* acting on the cyclist when his speed is $8.0\,m\,s^{-1}$. Use the value for the acceleration given in **(iii)**.

R = ... N [3]

(v) Use the information given in **(ii)** and your answer to **(iv)** to show that, in this situation, the resistive force *R* is proportional to the speed *v* of the cyclist.

[1]

For Examiner's Use

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]

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

For Examiner's Use

1 A cylindrical disc is shown in Fig. 1.1.

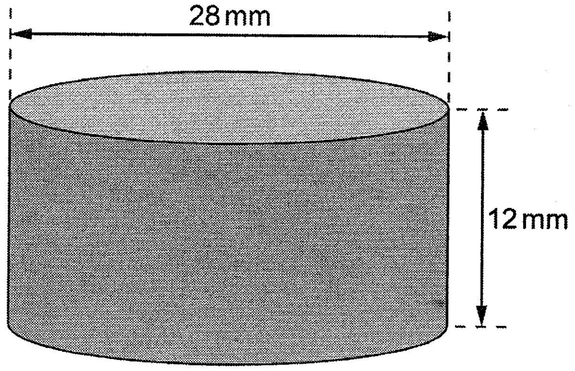

Fig. 1.1

The disc has diameter 28 mm and thickness 12 mm.
The material of the disc has density $6.8 \times 10^3\,\text{kg}\,\text{m}^{-3}$.

Calculate, to two significant figures, the weight of the disc.

weight = ... N [4]

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

For Examiner's Use

....

....

....[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.

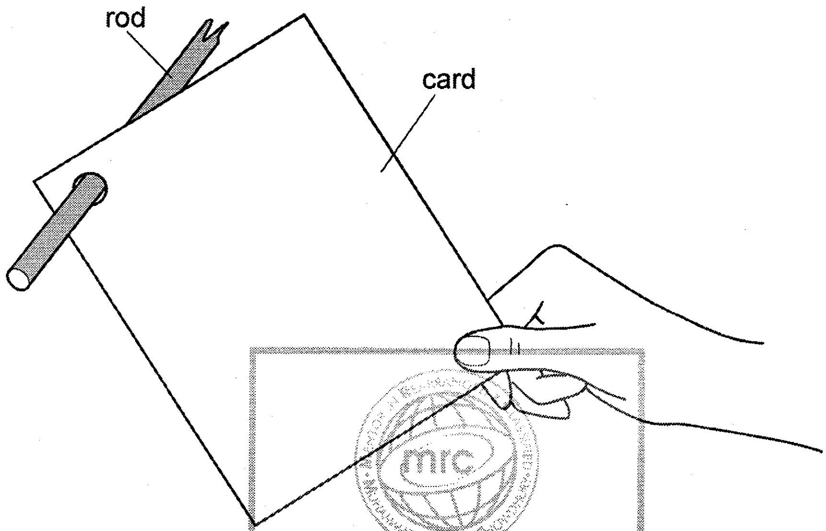

Fig. 3.1

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]

For Examiner's Use

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.

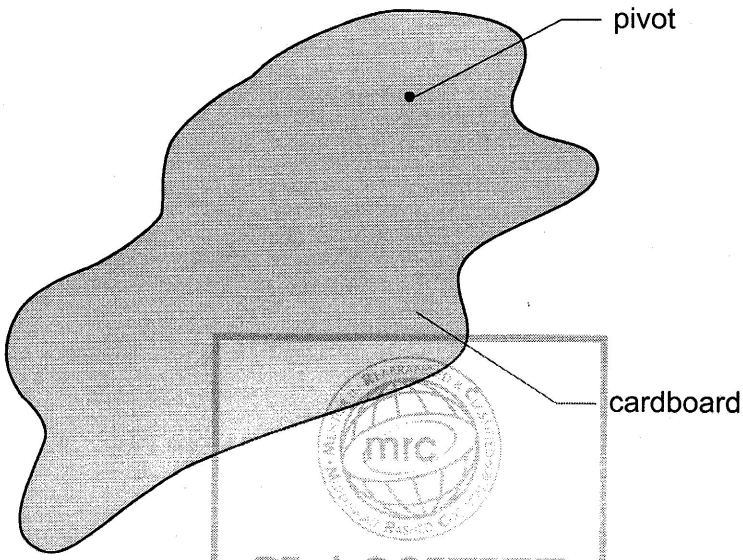

Fig. 2.1

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]