Q1.

2 **(a)** **(i)** Define displacement.

....

....

(ii) Use your definition to explain how it is possible for a car to travel a certain distance and yet have zero displacement.

....

....
[3]

(b) A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal, as illustrated in Fig. 2.1.

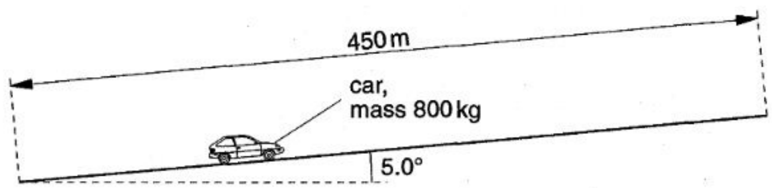


Fig. 2.1

The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28 m s^{-1} at the top of the slope.

(i) Determine, for this car travelling up the slope,

1. its acceleration,

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

2. the time taken to travel the length of the slope,

time taken = ... s [2]

Q2.

3 A student has been asked to determine the linear acceleration of a toy car as it moves down a slope. He sets up the apparatus as shown in Fig. 3.1.

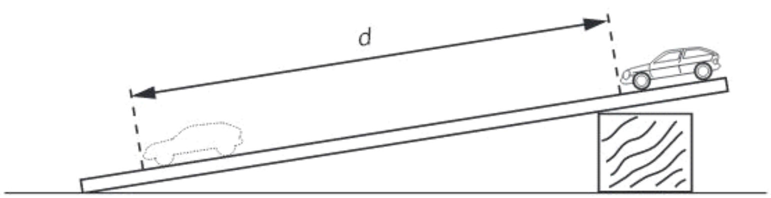
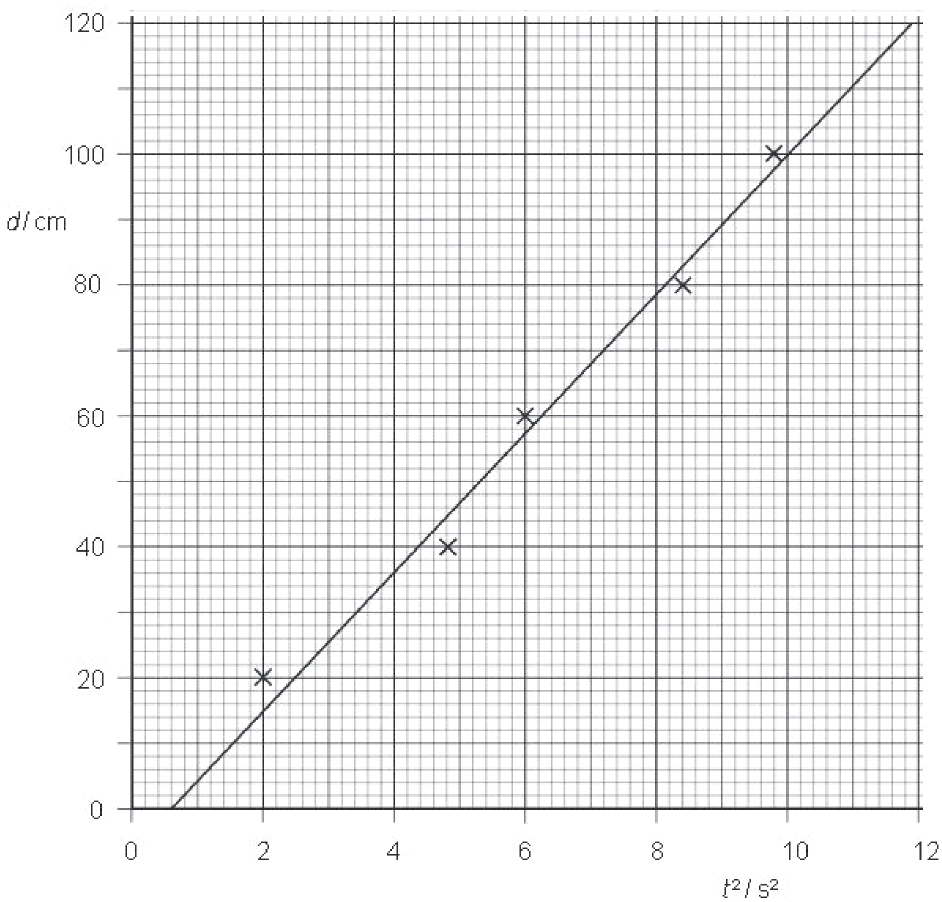


Fig. 3.1

The time t to move from rest through a distance d is found for different values of d. A graph of d (y-axis) is plotted against t^2 (x-axis) as shown in Fig. 3.2.



120
100
80
60
40
20
0
d / cm
0
2
4
6
8
10
12
t^2 / s^2

(a) Theory suggests that the graph is a straight line through the origin.
Name the feature on Fig. 3.2 that indicates the presence of

(i) random error,

....

(ii) systematic error.

....
[2]

(b) **(i)** Determine the gradient of the line of the graph in Fig. 3.2.

gradient = ... [2]

(ii) Use your answer to **(i)** to calculate the acceleration of the toy down the slope.
Explain your working.

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

Q3.

4 **(a)** A stone of mass 56 g is thrown horizontally from the top of a cliff with a speed of 18 m s^{-1}, as illustrated in Fig. 4.1.

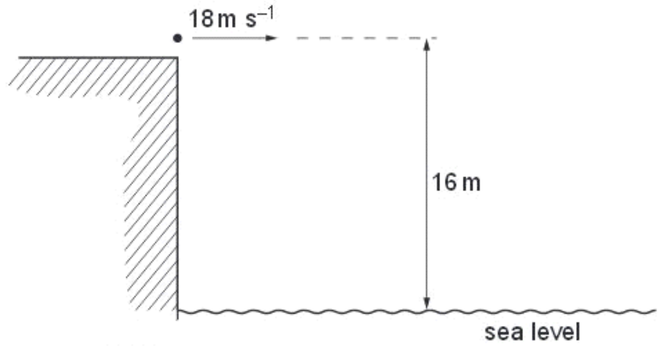


Fig. 4.1

The initial height of the stone above the level of the sea is 16 m. Air resistance may be neglected.

(c) State the horizontal velocity of the stone as it hits the water.

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

(d) **(i)** On the grid of Fig. 4.2, draw a vector diagram to represent the horizontal velocity and the resultant velocity of the stone as it hits the water. [1]

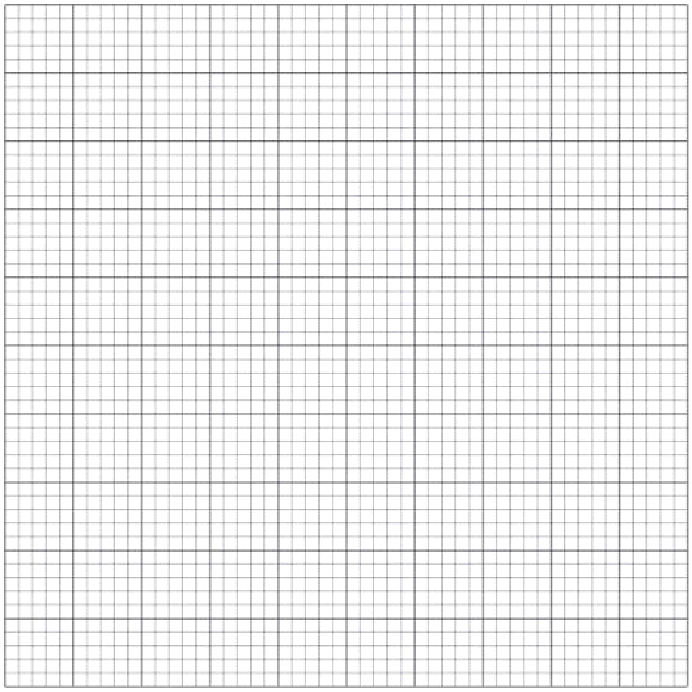


Fig. 4.2

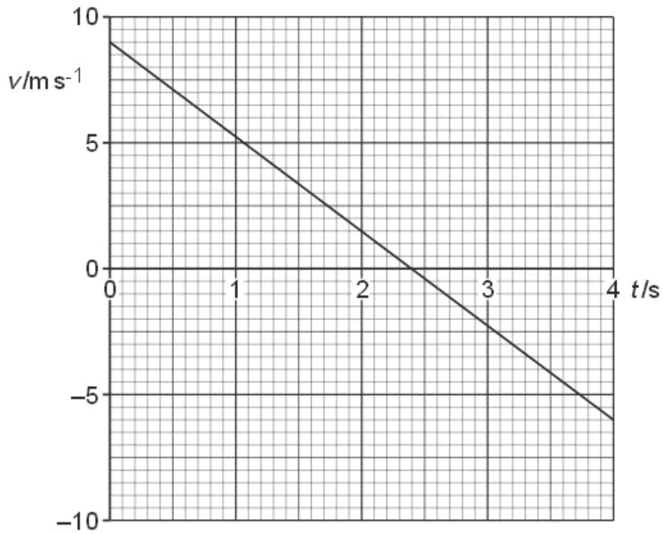
(ii) Use your vector diagram to determine the angle with the horizontal at which the stone hits the water.

angle = ... ° [2]

Q4.

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.

For Examiner's Use



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]

Q5.

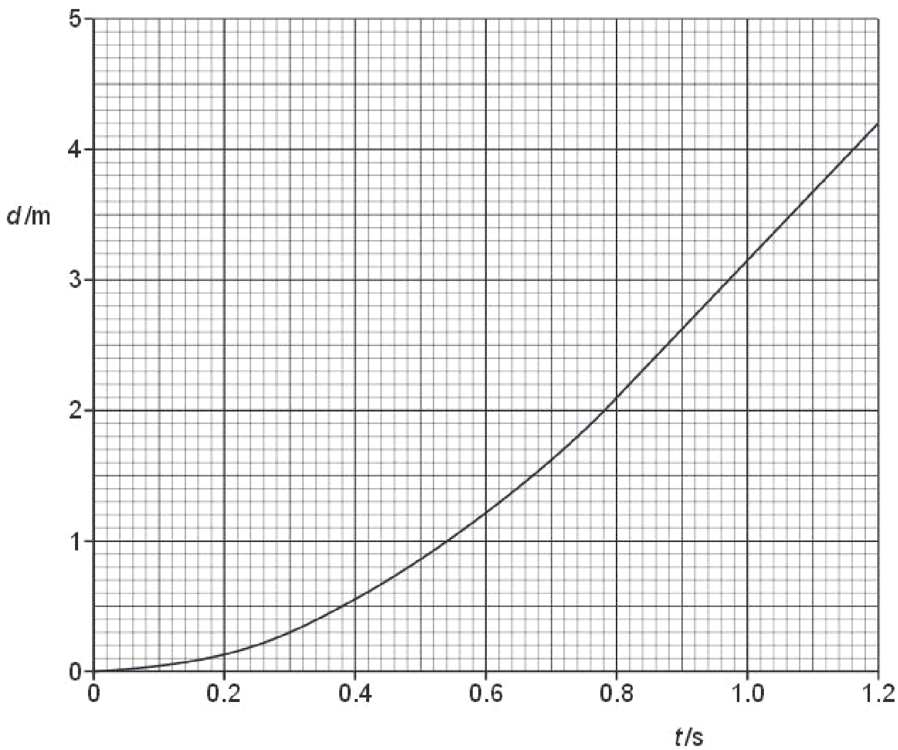
2 **(a)** Complete Fig. 2.1 to show whether each of the quantities listed is a vector or a scalar.

	vector / scalar
distance moved	....
speed	....
acceleration	....

Fig. 2.1

[3]

(b) A ball falls vertically in air from rest. The variation with time *t* of the distance *d* moved by the ball is shown in Fig. 2.2.



(i) By reference to Fig. 2.2, explain how it can be deduced that

For Examiner's Use

1. the ball is initially at rest,

....

....

.... [2]

2. air resistance is not negligible.

....

.... [1]

(ii) Use Fig. 2.2 to determine the speed of the ball at a time of 0.40 s after it has been released.

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

(iii) On Fig. 2.2, sketch a graph to show the variation with time *t* of the distance *d* moved by the ball for negligible air resistance. You are not expected to carry out any further calculations. [3]

Q6.

2 (a) The distance *s* moved by an object in time *t* may be given by the expression

$$s = \frac{1}{2}at^2$$

where *a* is the acceleration of the object.

State two conditions for this expression to apply to the motion of the object.

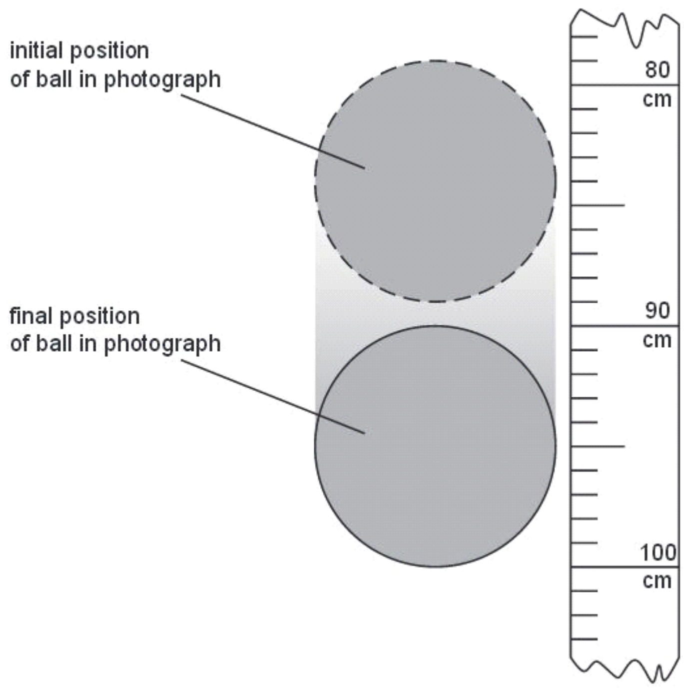
1. ....

....

2. ....

....
[2]

(b) A student takes a photograph of a steel ball of radius 5.0 cm as it falls from rest. The image of the ball is blurred, as illustrated in Fig. 2.1.
The image is blurred because the ball is moving while the photograph is being taken.



The scale shows the distance fallen from rest by the ball. At time $t = 0$, the top of the ball is level with the zero mark on the scale. Air resistance is negligible.

Calculate, to an appropriate number of significant figures,

(i) the time the ball falls before the photograph is taken,

time = ... s [3]

(ii) the time interval during which the photograph is taken.

time interval = ... s [3]

(c) The student in **(b)** takes a second photograph starting at the same position on the scale. The ball has the same radius but is less dense, so that air resistance is not negligible.

State and explain the changes that will occur in the photograph.

....

....

....

....[2]

Q7.

3 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8.0 s to climb the slope.
The variation with time t of the speed v of the cyclist is shown in Fig. 3.1.

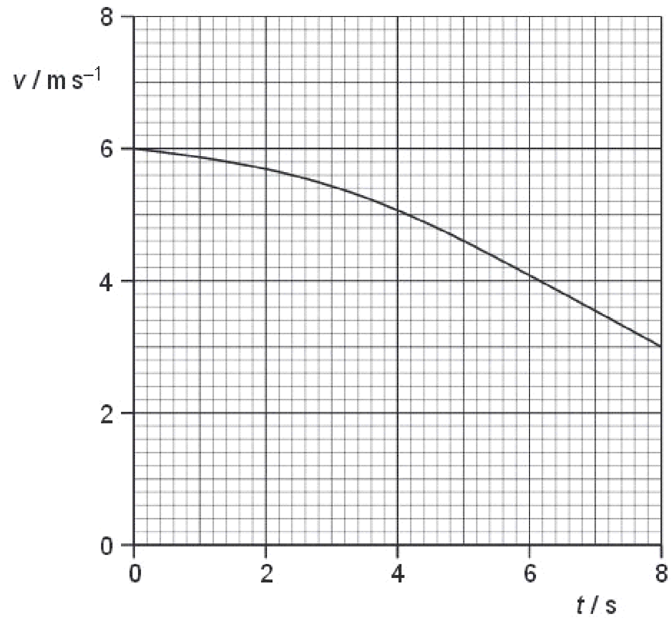


Fig. 3.1

(a) Use Fig. 3.1 to determine the total distance moved up the slope.

distance = ... m [3]

Q8.

1 **(a)** Distinguish between *scalar* quantities and *vector* quantities.

....

....

.... [2]

(b) In the following list, underline **all** the scalar quantities.

acceleration force kinetic energy mass power weight [1]

(c) A stone is thrown with a horizontal velocity of $20\,m\,s^{-1}$ from the top of a cliff 15 m high. The path of the stone is shown in Fig. 1.1.

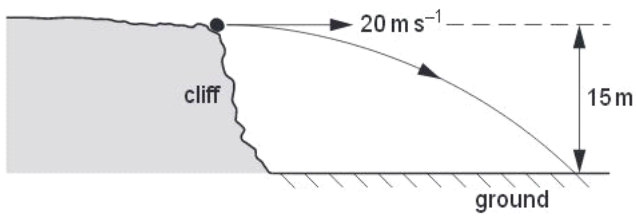


Fig. 1.1

Air resistance is negligible.

For this stone,

(i) calculate the time to fall 15 m,

time = ... s [2]

(ii) calculate the magnitude of the resultant velocity after falling 15 m,

resultant velocity = ... $m\,s^{-1}$ [3]

(iii) describe the difference between the displacement of the stone and the distance that it travels.

....

....

.... **[2]**

Q9.

2 **(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

$$F = 6\pi DRv$$

where D depends on the fluid.

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

[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.

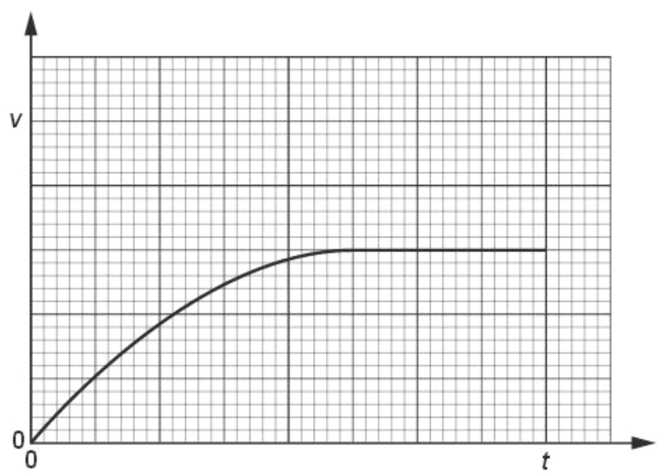


Fig. 2.1

(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]

Q10.

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

Ex

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

[2]

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

distance = ... m [2]

Q11.

2 **(a)** A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 2.1.

Ex

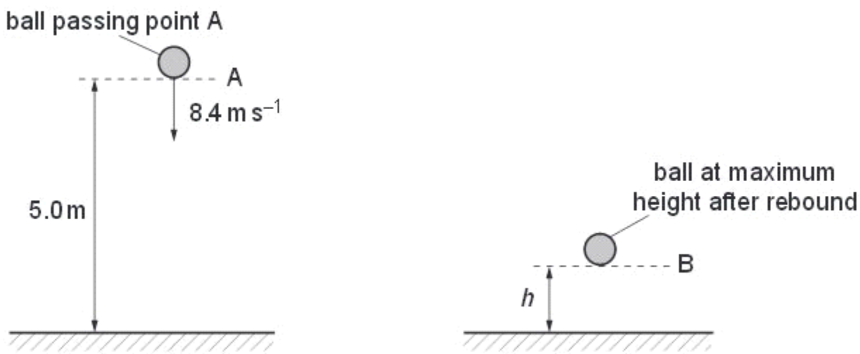


Fig. 2.1

As the ball passes A, it has a speed of $8.4\,\text{m}\,\text{s}^{-1}$. The height of A is 5.0 m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

(i) Calculate the speed of the ball as it hits the ground.

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

(ii) Show that the time taken for the ball to reach the ground is 0.47 s.

[1]

(b) The ball rebounds vertically with a speed of $4.2\,\text{m s}^{-1}$ as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height *h*.

The ball passes A at time $t = 0$. On Fig. 2.2, plot a graph to show the variation with time *t* of the velocity *v* of the ball. Continue the graph until the ball has rebounded from the ground and reaches B.

Fig. 2.2 [3]

Q12.

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

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.

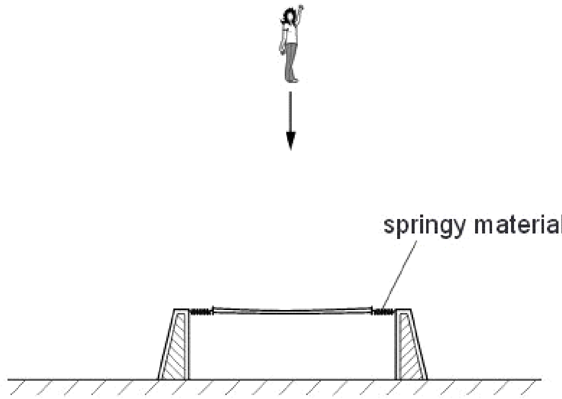


Fig. 2.2

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.

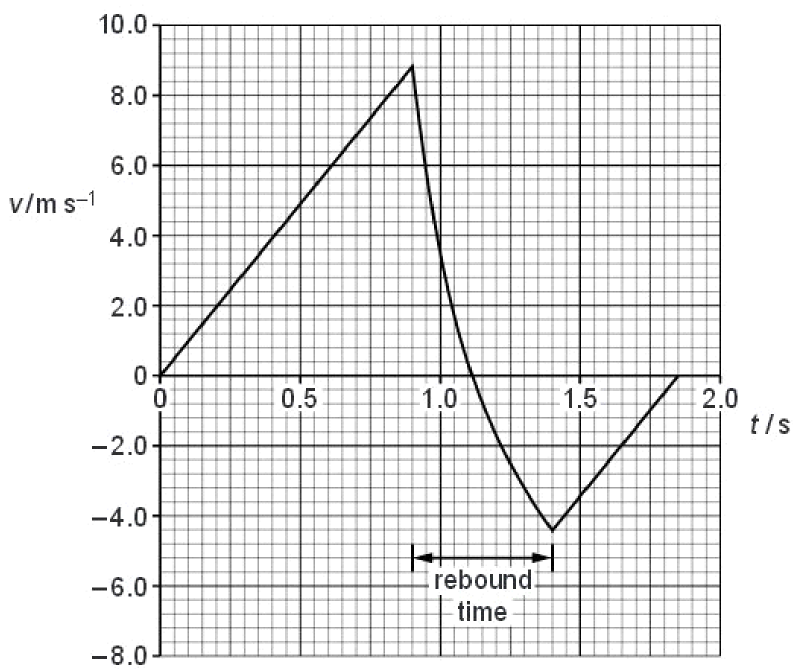


Fig. 2.3

For the motion of the girl, calculate

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

distance = ... m [2]

(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]

Q13.

3 A ball falls from rest onto a flat horizontal surface. Fig. 3.1 shows the variation with time t of the velocity v of the ball as it approaches and rebounds from the surface.

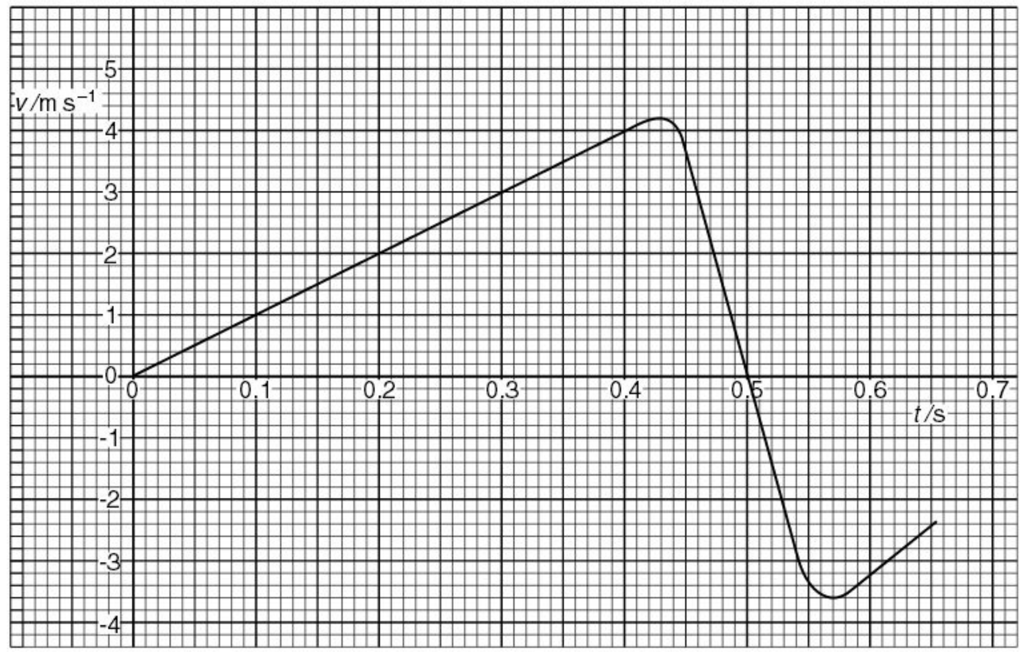


Fig. 3.1

Use data from Fig. 3.1 to determine

(a) the distance travelled by the ball during the first 0.40 s,

distance = ... m [2]

Use

(b) the change in momentum of the ball, of mass 45 g, during contact of the ball with the surface,

change = ... N s [4]

(c) the average force acting on the ball during contact with the surface.

force = ... N [2]

Q14.

1 **(a)** One of the equations of motion may be written as

$$v^2 = u^2 + 2as.$$

(i) Name the quantity represented by the symbol *a*.

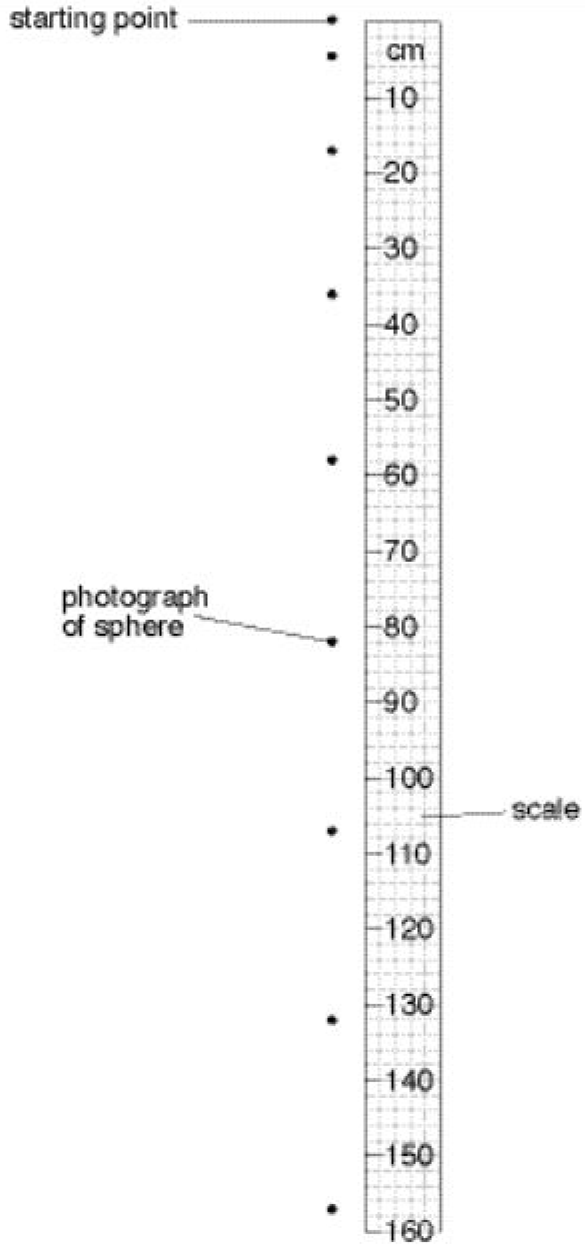
....

(ii) The quantity represented by the symbol *a* may be either positive or negative. State the significance of a negative value.

....

[2]

(b) A student investigates the motion of a small polystyrene sphere as it falls from rest alongside a vertical scale marked in centimetres. To do this, a number of flash photographs of the sphere are taken at 0.1 s intervals, as shown in Fig. 1.1.



The first photograph is taken at time $t = 0$.

By reference to Fig. 1.1,

(i) briefly explain how it can be deduced that the sphere reaches a constant speed,

....

....

(ii) determine the distance that the sphere has fallen from rest during a time of

1. 0.7 s,

distance = ... cm

2. 1.1 s.

distance = ... cm
[4]

(c) The student repeats the experiment with a lead sphere that falls with constant acceleration and does not reach a constant speed.

Determine the number of flash photographs that will be observed against the 160 cm scale.

Include in your answer the photograph obtained at time $t = 0$.

number = ... [3]

Q15.

3 A girl stands at the top of a cliff and throws a ball vertically upwards with a speed of $12\,m\,s^{-1}$, as illustrated in Fig. 3.1.

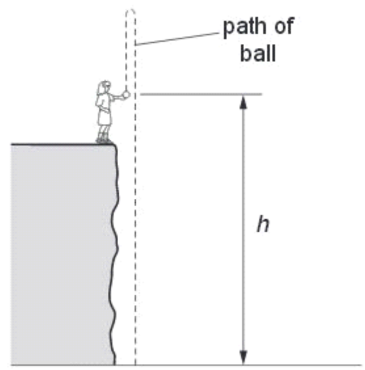
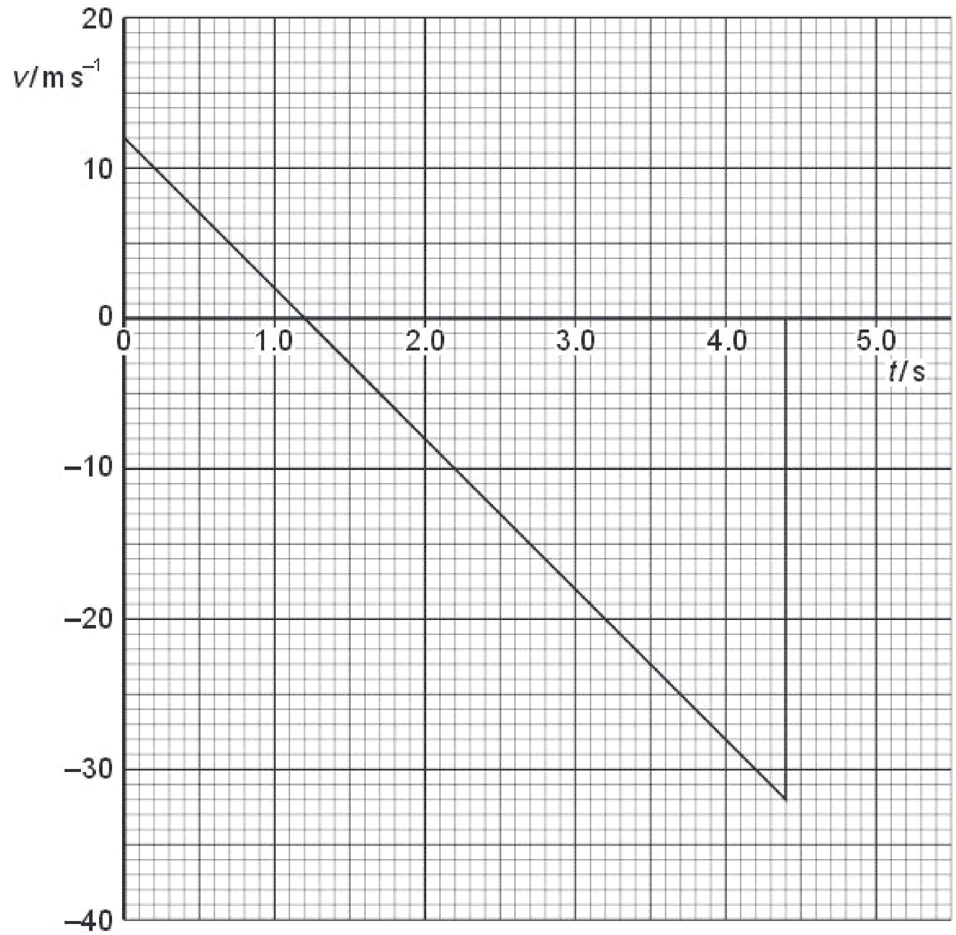


Fig. 3.1

At the time that the girl throws the ball, her hand is a height h above the horizontal ground at the base of the cliff.
The variation with time t of the speed v of the ball is shown in Fig. 3.2.



Speeds in the upward direction are shown as being positive. Speeds in the downward direction are negative.

For Examiner's Use

(a) State the feature of Fig. 3.2 that shows that the acceleration is constant.

.... [1]

(b) Use Fig. 3.2 to determine the time at which the ball

(i) reaches maximum height,

time = ... s

(ii) hits the ground at the base of the cliff.

time = ... s
[2]

(c) Determine the maximum height above the base of the cliff to which the ball rises.

height = ... m [3]

(d) The ball has mass 250 g. Calculate the magnitude of the change in momentum of the ball between the time that it leaves the girl's hand to time t = 4.0 s.

change = ... Ns [3]

(e) **(i)** State the principle of conservation of momentum.

....

....

.... [2]

(ii) Comment on your answer to **(d)** by reference to this principle.

....

....

....

.... [3]

Q16.

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

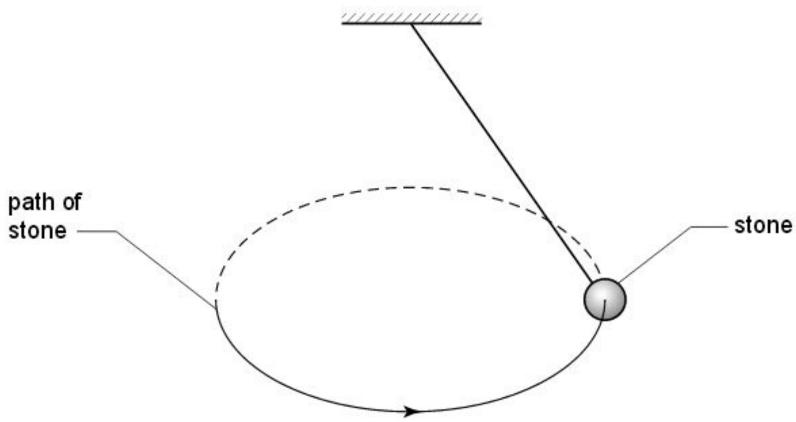


Fig. 3.1

The stone has a constant speed.

(a) Define *acceleration*.

....

.... [1]

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

....

....

.... [2]

Q17.

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

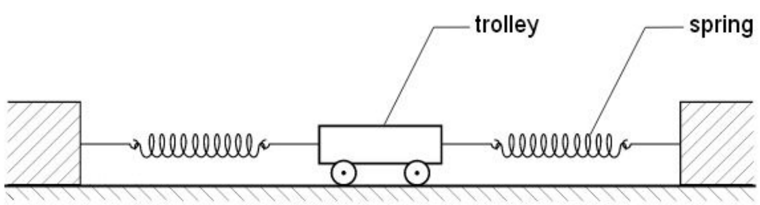


Fig. 4.1

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.

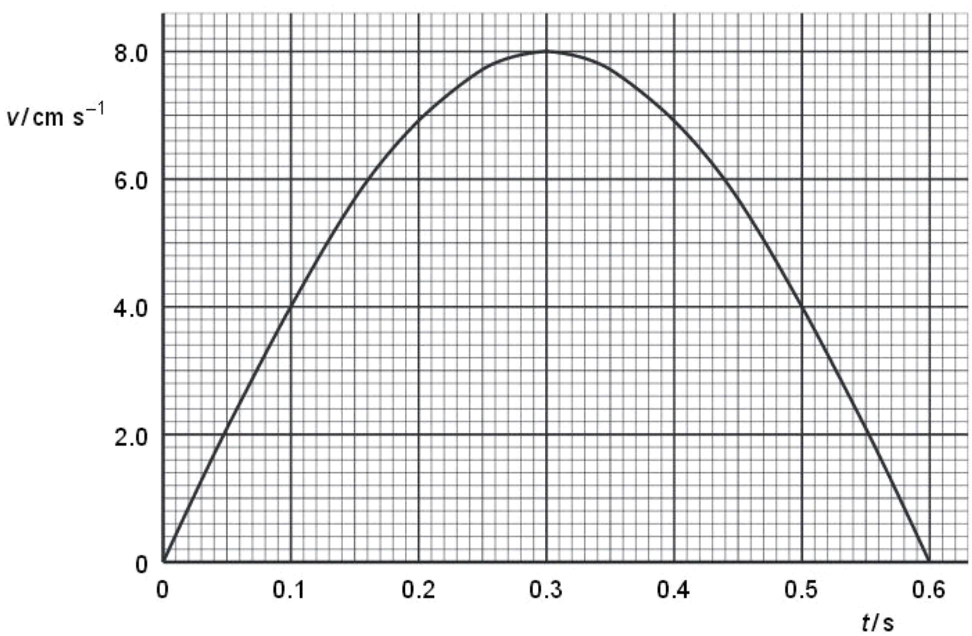


Fig. 4.2

(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]

Q18.

2 A student investigates the speed of a trolley as it rolls down a slope, as illustrated in Fig. 2.1.

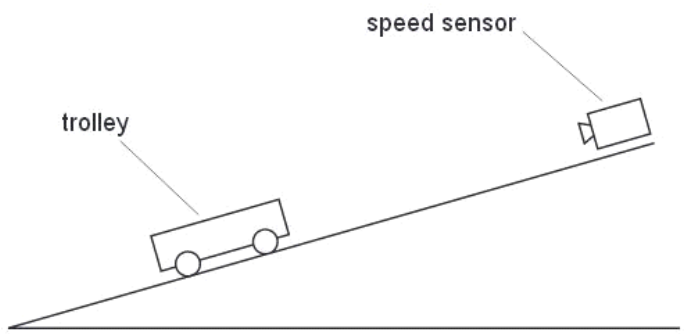


Fig. 2.1

The speed *v* of the trolley is measured using a speed sensor for different values of the time *t* that the trolley has moved from rest down the slope.

Fig. 2.2 shows the variation with *t* of *v*.

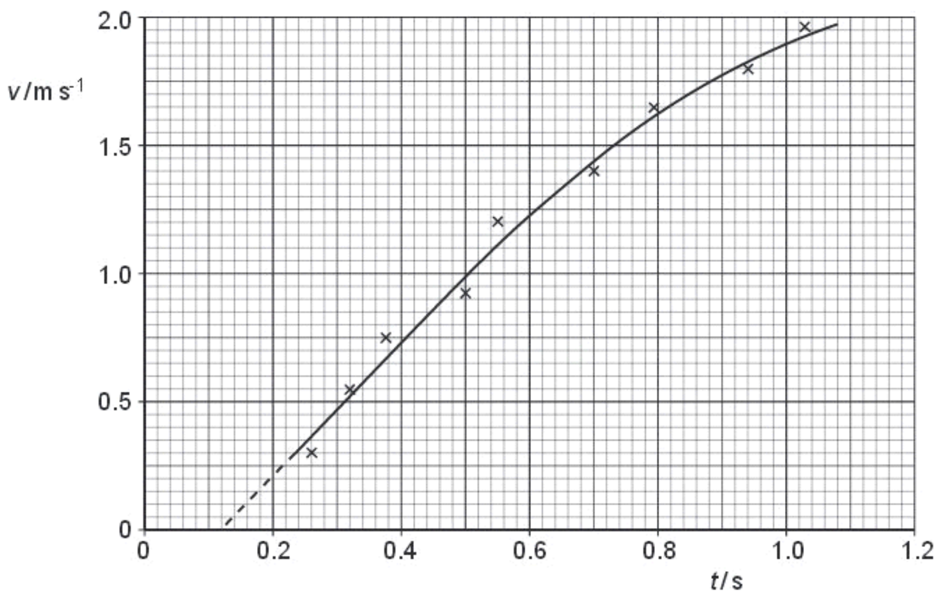


Fig. 2.2

(a) Use Fig. 2.2 to determine the acceleration of the trolley at the point on the graph where t = 0.80 s.

For Examiner's Use

acceleration = ……………………………… m s^{-2} **[4]**

(b) **(i)** State whether the acceleration is increasing or decreasing for values of t greater than 0.6 s. Justify your answer by reference to Fig. 2.2.

……

……

………………………………………………………………………………………………… **[2]**

(ii) Suggest an explanation for this change in acceleration.

....

.... [1]

(c) Name the feature of Fig. 2.2 that indicates the presence of

(i) random error,

....

.... [1]

(ii) systematic error.

....

.... [1]

Q19.

2 A girl G is riding a bicycle at a constant velocity of $3.5\,\text{m}\,\text{s}^{-1}$. At time $t = 0$, she passes a boy B sitting on a bicycle that is stationary, as illustrated in Fig. 2.1.

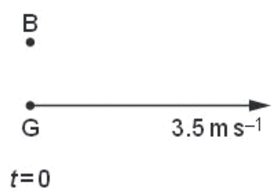


Fig. 2.1

At time $t = 0$, the boy sets off to catch up with the girl. He accelerates uniformly from time $t = 0$ until he reaches a speed of $5.6\,\text{m}\,\text{s}^{-1}$ in a time of 5.0 s. He then continues at a constant speed of $5.6\,\text{m}\,\text{s}^{-1}$. At time $t = T$, the boy catches up with the girl.
T is measured in seconds.

(a) State, in terms of T, the distance moved by the girl before the boy catches up with her.

distance = ... m [1]

(b) For the boy, determine

(i) the distance moved during his acceleration,

distance = ... m [2]

(ii) the distance moved during the time that he is moving at constant speed.
Give your answer in terms of *T*.

distance = ... m [1]

(c) Use your answers in **(a)** and **(b)** to determine the time *T* taken for the boy to catch up with the girl.

T = ... s [2]

(d) The boy and the bicycle have a combined mass of 67 kg.

(i) Calculate the force required to cause the acceleration of the boy.

force = ... N [3]

(ii) At a speed of $4.5\,m\,s^{-1}$, the total resistive force acting on the boy and bicycle is 23 N.
Determine the output power of the boy's legs at this speed.

power = ... W [2]

Q20.

2 A car is travelling along a straight road at speed v. A hazard suddenly appears in front of the car. In the time interval between the hazard appearing and the brakes on the car coming into operation, the car moves forward a distance of 29.3 m. With the brakes applied, the front wheels of the car leave skid marks on the road that are 12.8 m long, as illustrated in Fig. 2.1.

For Examiner's Use

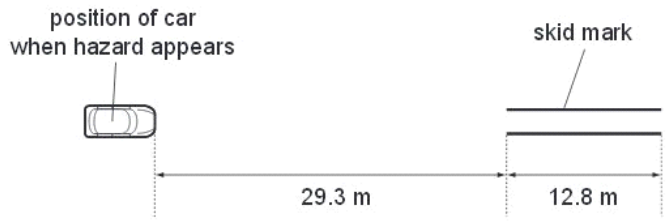


Fig. 2.1

It is estimated that, during the skid, the magnitude of the deceleration of the car is 0.85 g, where g is the acceleration of free fall.

(a) Determine

(i) the speed v of the car before the brakes are applied,

v = …………………… $m\,s^{-1}$ [2]

(ii) the time interval between the hazard appearing and the brakes being applied.

time = …………….………… s [2]

(b) The legal speed limit on the road is 60 km per hour.
Use both of your answers in **(a)** to comment on the standard of the driving of the car.

....

....

....

.... [3]

Q21.

2 A sky-diver jumps from a high-altitude balloon.

(a) Explain briefly why the acceleration of the sky-diver

(i) decreases with time,

....

....

.... [2]

(ii) is $9.8\,m\,s^{-2}$ at the start of the jump.

....

.... [1]

(b) The variation with time *t* of the vertical speed *v* of the sky-diver is shown in Fig. 2.1.

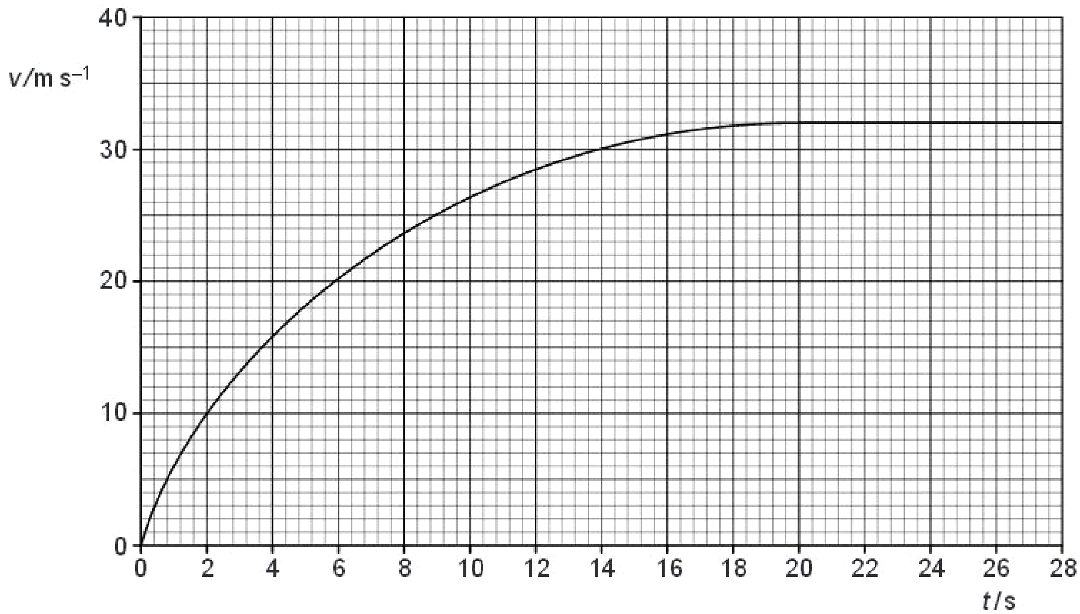


Fig. 2.1

Use Fig. 2.1 to determine the magnitude of the acceleration of the sky-diver at time t = 6.0 s.

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

(c) The sky-diver and his equipment have a total mass of 90 kg.

(i) Calculate, for the sky-diver and his equipment,

1. the total weight,

weight = ... N [1]

2. the accelerating force at time $t = 6.0\,s$.

force = ... N [1]

(ii) Use your answers in (i) to determine the total resistive force acting on the sky-diver at time $t = 6.0\,s$.

force = ... N [1]

Q22.

3 A small ball is thrown horizontally with a speed of $4.0\,m\,s^{-1}$. It falls through a vertical height of 1.96 m before bouncing off a horizontal plate, as illustrated in Fig. 3.1.

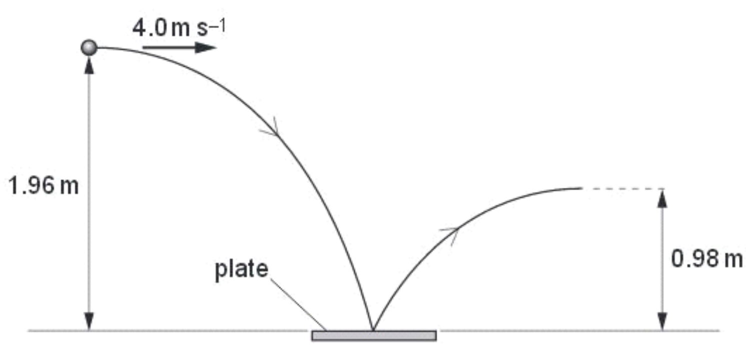


Fig. 3.1

Air resistance is negligible.

(a) For the ball, as it hits the horizontal plate,

(i) state the magnitude of the horizontal component of its velocity,

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

(ii) show that the vertical component of the velocity is 6.2 m s^{-1}.

[1]

(b) The components of the velocity in **(a)** are both vectors.

For Examiner's Use

Complete Fig. 3.2 to draw a vector diagram, to scale, to determine the velocity of the ball as it hits the horizontal plate.

Fig. 3.2

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

at .... ° to the vertical
[3]

(c) After bouncing on the plate, the ball rises to a vertical height of 0.98 m.

(i) Calculate the vertical component of the velocity of the ball as it leaves the plate.

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

(ii) The ball of mass 34 g is in contact with the plate for a time of 0.12 s.

For Examiner Use

Use your answer in **(c)(i)** and the data in **(a)(ii)** to calculate, for the ball as it bounces on the plate,

1. the change in momentum,

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

2. the magnitude of the average force exerted by the plate on the ball due to this momentum change.

force = ... N [2]

Q23.

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

For Examiner's Use

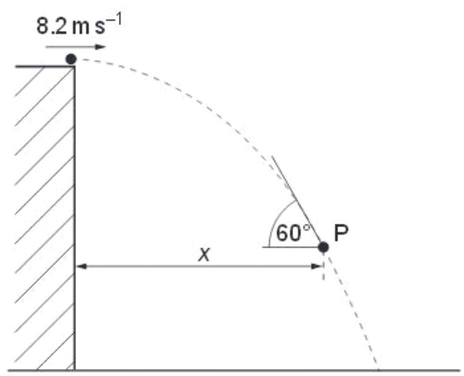


Fig. 2.1

The ball is thrown with a horizontal speed of $8.2\,m\,s^{-1}$. 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 m s^{-1},

[2]

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

distance = ... m [2]

(iii) determine the horizontal distance *x*.

Ex

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.

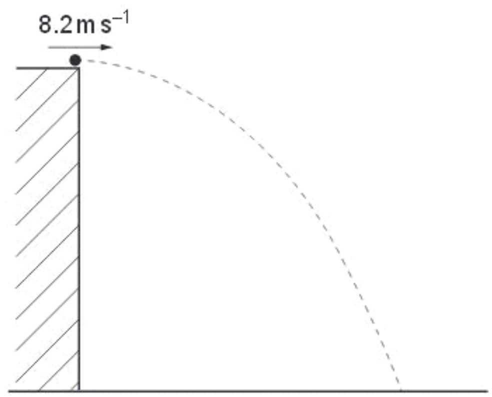


Fig. 2.2

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]

Q24.

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

For Examiner's Use

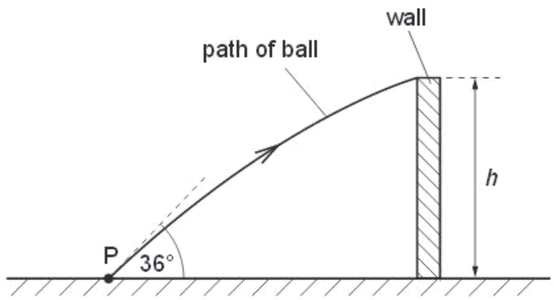


Fig. 2.1

The initial velocity of the ball is 12.4 m 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.

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]

Q25.

4 A student takes measurements to determine a value for the acceleration of free fall. Some of the apparatus used is illustrated in Fig. 4.1.

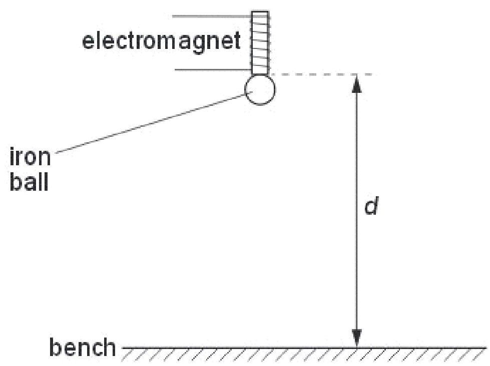
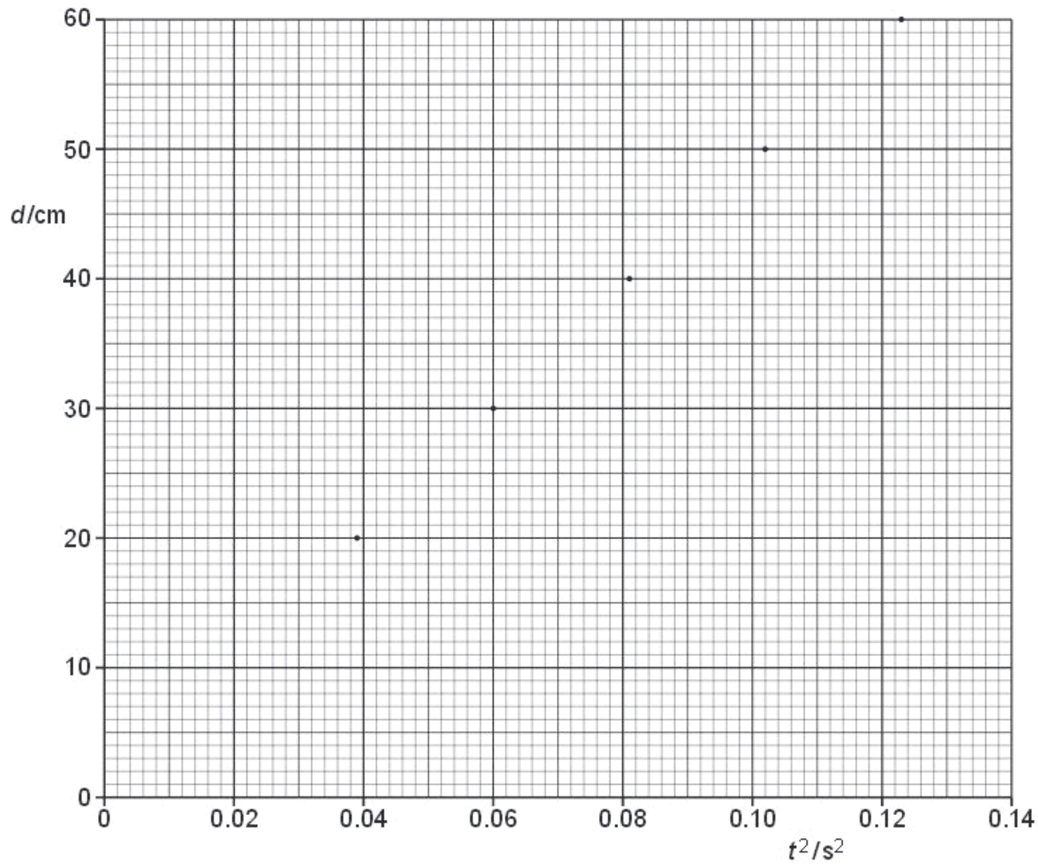


Fig. 4.1

The student measures the vertical distance *d* between the base of the electromagnet and the bench. The time *t* for an iron ball to fall from the electromagnet to the bench is also measured.
Corresponding values of t^2 and *d* are shown in Fig. 4.2.



(a) On Fig. 4.2, draw the line of best fit for the points. [1]

(b) State and explain why there is a non-zero intercept on the graph of Fig. 4.2.

....

....

.... [2]

(c) Determine the student's value for

(i) the diameter of the ball,

diameter = ... cm [1]

(ii) the acceleration of free fall.

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

Q26.

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

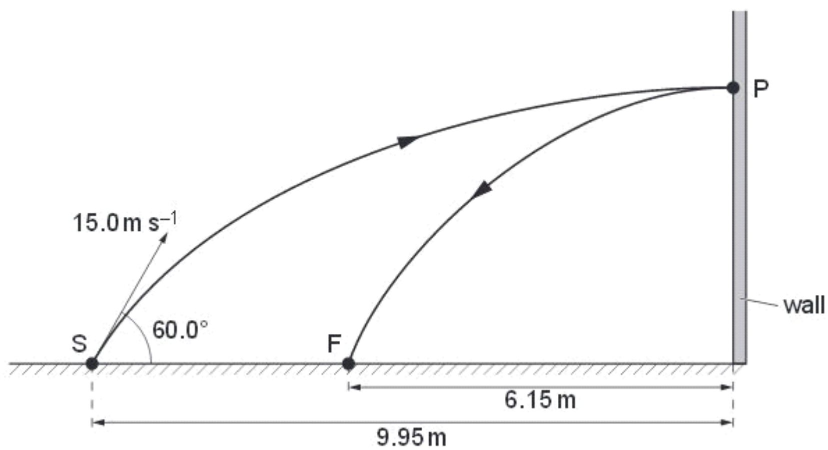


Fig. 3.1 (not to scale)

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,

[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]

Q27.

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

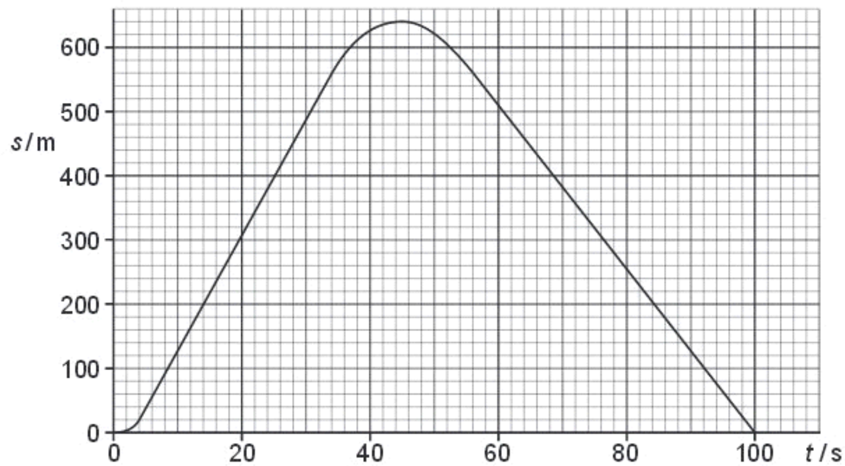


Fig. 1.1

(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.

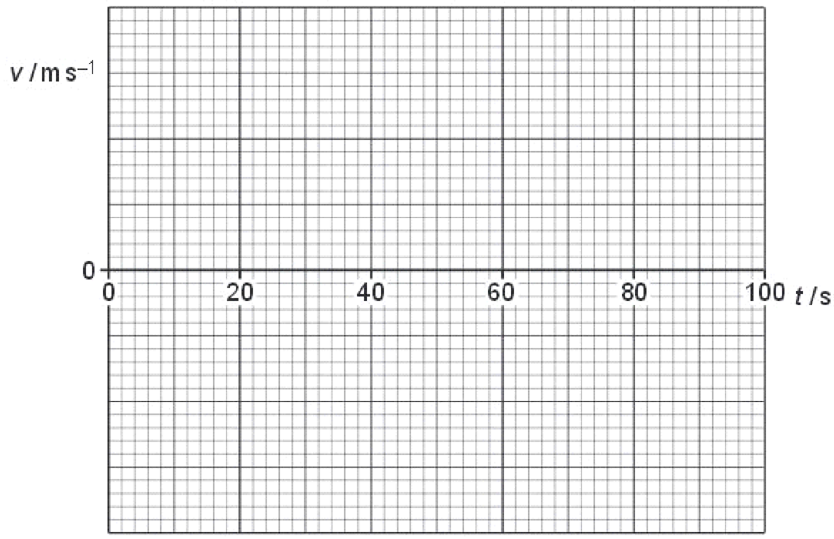


Fig. 1.2

[4]

Q28.

2 The variation with time t of velocity v of a car is shown in Fig. 2.1.

For Examiner Use

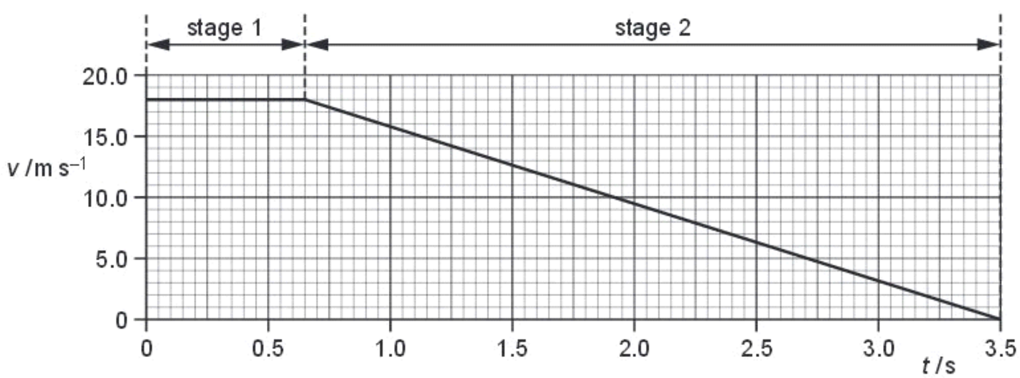


Fig. 2.1

At time t = 0, the driver sees an obstacle in the road. A short time later, the driver applies the brakes. The car travels in two stages, as shown in Fig. 2.1.

(a) Use Fig. 2.1 to describe the velocity of the car in

1. stage 1,

....

....[1]

2. stage 2.

....

....[1]

(b) **(i)** Calculate the distance travelled by the car from t = 0 to t = 3.5 s.

total distance = ... m [2]

(ii) The car has a total mass of 1250 kg. Determine the total resistive force acting on the car in stage 2.

For Examiner's Use

force = ... N [3]

(c) For safety reasons drivers are asked to travel at lower speeds. For each stage, describe and explain the effect on the distance travelled for the same car and driver travelling at half the initial speed shown in Fig. 2.1.

(i) stage 1:

....

....

....[1]

(ii) stage 2:

....

....

....

....[2]

Q29.

1 **(a)** The drag force D on an object of cross-sectional area A, moving with a speed v through a fluid of density ρ, is given by

$$D = \frac{1}{2} C\rho A v^2$$

where C is a constant.

Show that C has no unit.

[2]

(b) A raindrop falls vertically from rest. Assume that air resistance is negligible.

(i) On Fig. 1.1, sketch a graph to show the variation with time *t* of the velocity *v* of the raindrop for the first 1.0 s of the motion.

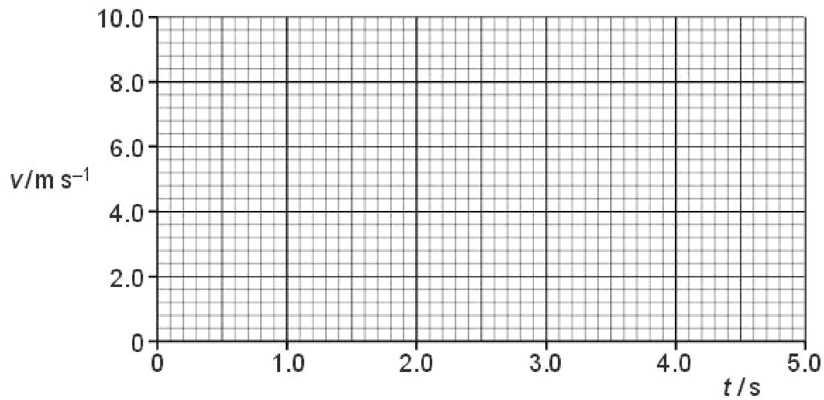


Fig. 1.1

[1]

(ii) Calculate the velocity of the raindrop after falling 1000 m.

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

(c) In practice, air resistance on raindrops is not negligible because there is a drag force. This drag force is given by the expression in **(a)**.

(i) State an equation relating the forces acting on the raindrop when it is falling at terminal velocity.

[1]

(ii) The raindrop has mass 1.4×10^{-5} kg and cross-sectional area 7.1×10^{-6} m^2. The density of the air is 1.2 kg m^{-3} and the initial velocity of the raindrop is zero. The value of C is 0.60.

1. Show that the terminal velocity of the raindrop is about 7 m s^{-1}.

[2]

2. The raindrop reaches terminal velocity after falling approximately 10 m. On Fig. 1.1, sketch the variation with time t of velocity v for the raindrop. The sketch should include the first 5 s of the motion.

[2]

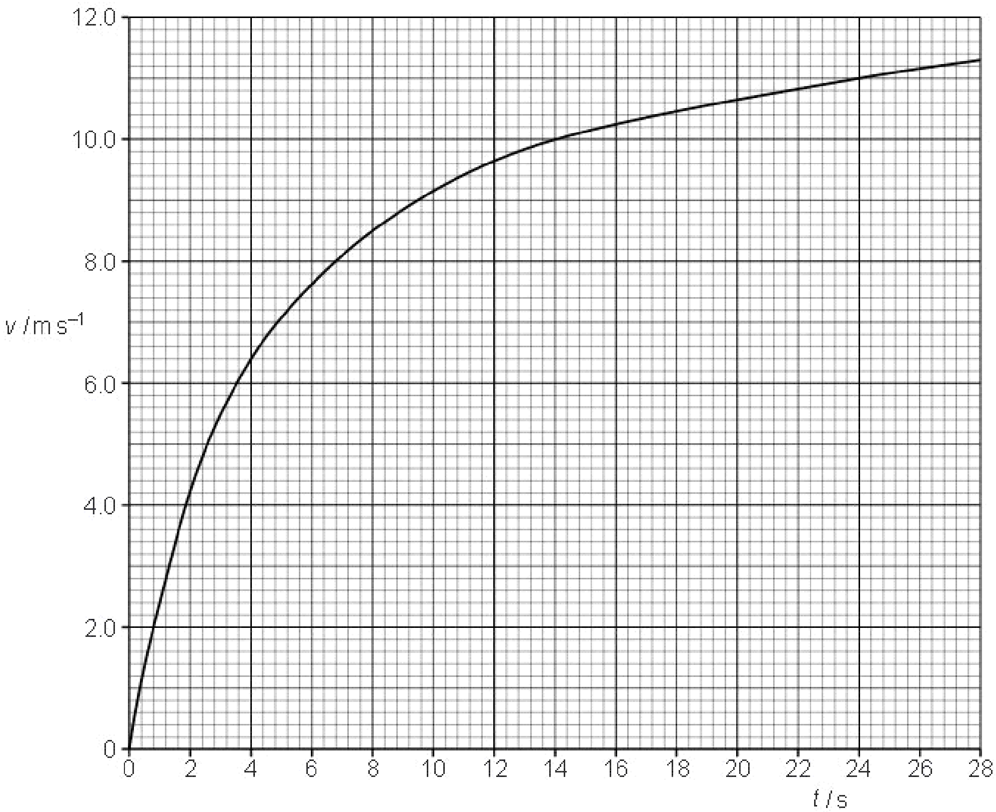
Q30.

3 **(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.



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 48N. Show that the power of the cyclist is about 600W. Explain your working.

Ex

[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 80kg. 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]

Q31.

3 (a) Define

For Examiner Use

(i) *velocity*,

....

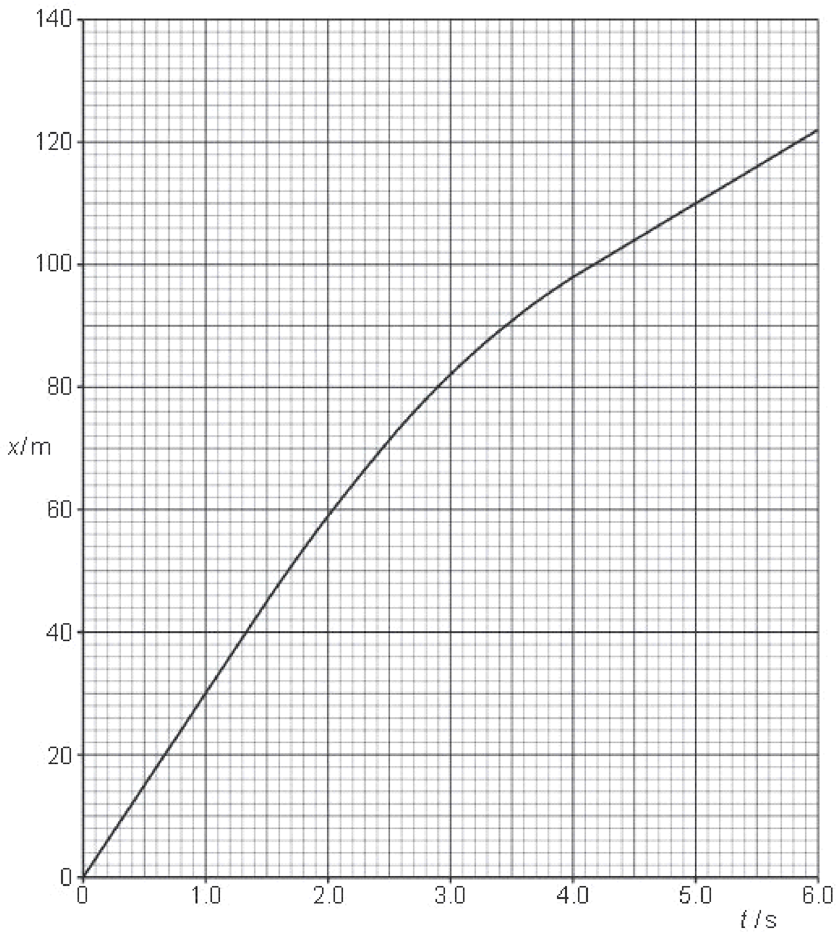
....[1]

(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.



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 $t = 1.5$ s.

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

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

[2]

(iv) Calculate the average force acting on the car between $t = 1.5$ s and $t = 4.0$ s.

force = ... N [2]