

# Equations of Motion

## Question paper 1

<b>Level</b>	International A Level
<b>Subject</b>	Physics
<b>Exam Board</b>	CIE
<b>Topic</b>	Kinematics
<b>Sub Topic</b>	Equations of Motion
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question paper 1

**Time Allowed:** 84 minutes

**Score:** /70

**Percentage:** /100

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

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

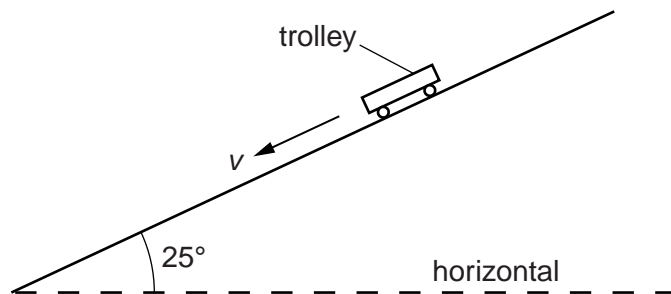


Fig. 4.1

The slope makes an angle of  $25^\circ$  with the horizontal. A constant resistive force  $F_R$  acts up the slope on the trolley.

At time  $t = 0$ , the trolley has velocity  $v = 0.50 \text{ m s}^{-1}$  down the slope.

At time  $t = 4.0 \text{ s}$ ,  $v = 12 \text{ m s}^{-1}$  down the slope.

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

[2]

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

$x = \dots\dots\dots \text{ m}$  [2]

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

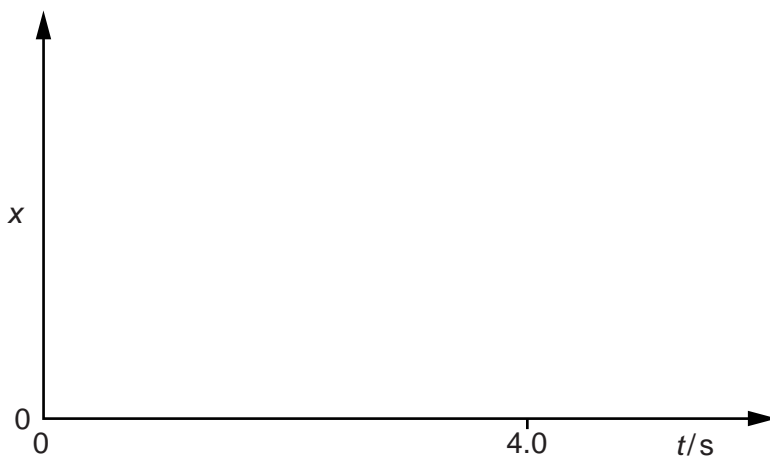


Fig. 4.2

[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  $F_R$ .

$F_R = \dots\dots\dots$  N [2]

- 2 A ball is thrown from A to B as shown in Fig. 2.1.

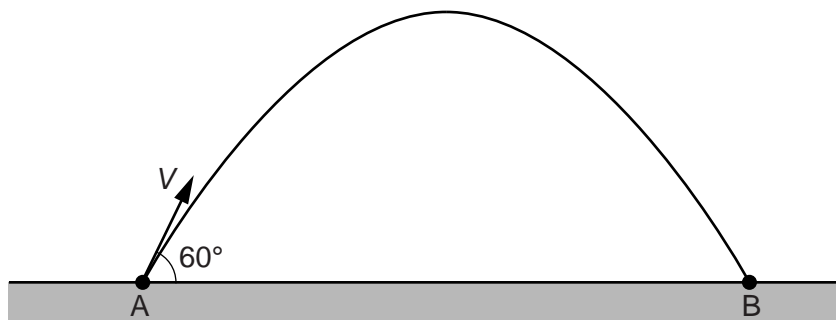


Fig. 2.1

The ball is thrown with an initial velocity  $V$  at  $60^\circ$  to the horizontal.

The variation with time  $t$  of the vertical component  $V_v$  of the velocity of the ball from  $t = 0$  to  $t = 0.60$  s is shown in Fig. 2.2.

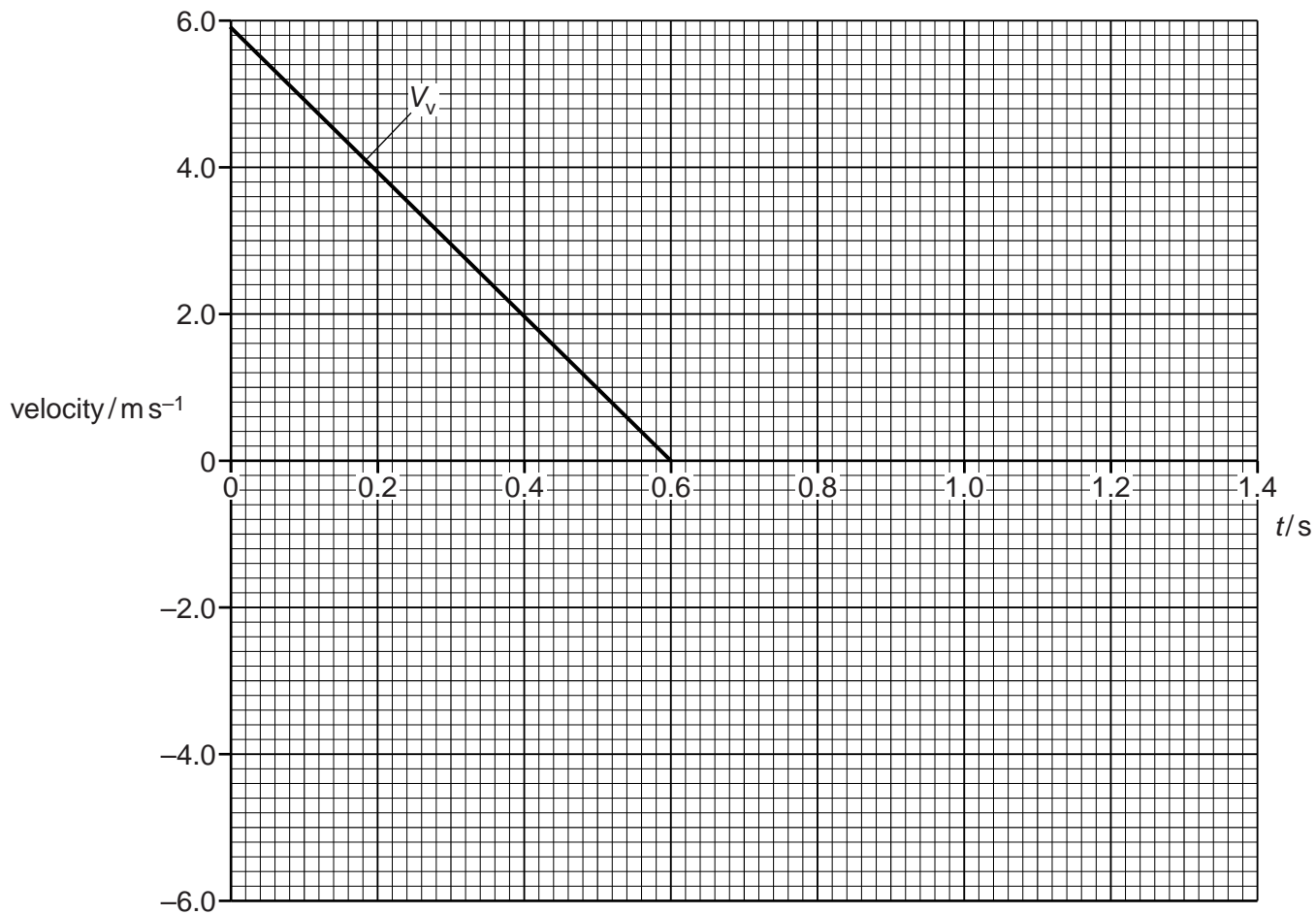


Fig. 2.2

Assume air resistance is negligible.

- (a) (i) Complete Fig. 2.2 for the time until the ball reaches B. [2]
- (ii) Calculate the maximum height reached by the ball.

height = .....m [2]

- (iii) Calculate the horizontal component  $V_h$  of the velocity of the ball at time  $t = 0$ .

$V_h = \dots\dots\dots \text{ms}^{-1}$  [2]

- (iv) On Fig. 2.2, sketch the variation with  $t$  of  $V_h$ . **Label** this sketch  $V_h$ . [1]

- (b) The ball has mass 0.65 kg.  
Calculate, for the ball,

- (i) the maximum kinetic energy,

maximum kinetic energy = .....J [3]

- (ii) the maximum potential energy above the ground.

maximum potential energy = .....J [2]

- 3 (a) Explain what is meant by a *scalar* quantity and by a *vector*

scalar: .....quantity.....

.....

vector: .....

.....

[2]

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

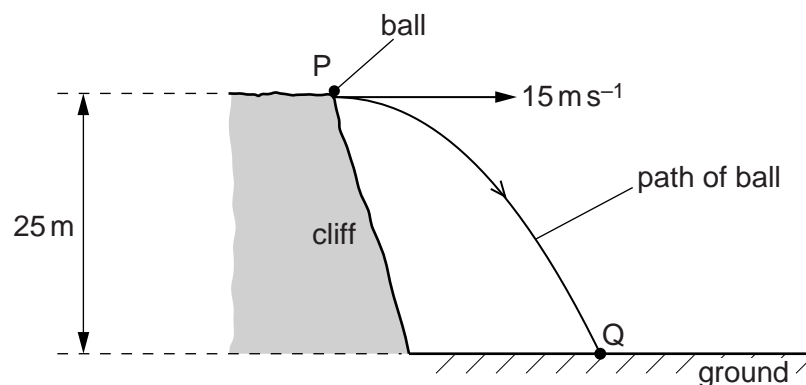


Fig. 2.1

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

- 4 (a) The drag force  $D$  on an object of cross-sectional area  $A$ , moving with a speed  $v$  through a fluid of density  $\rho$ , 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 1.0s of the motion.

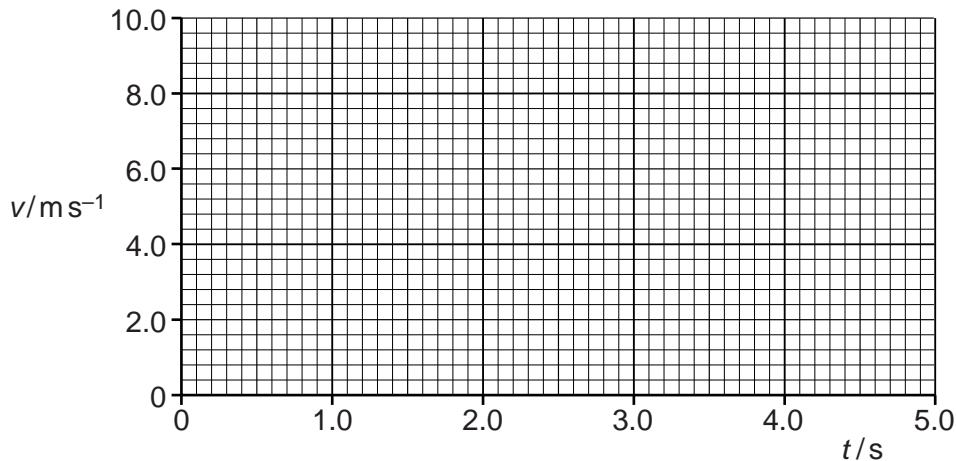


Fig. 1.1

[1]

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

velocity = .....  $\text{ms}^{-1}$  [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  $1.4 \times 10^{-5} \text{ kg}$  and cross-sectional area  $7.1 \times 10^{-6} \text{ m}^2$ . The density of the air is  $1.2 \text{ kg m}^{-3}$  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  $7 \text{ m s}^{-1}$ .

[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]

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

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

[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  $12.5 \text{ ms}$  and rebounds with an upwards velocity of  $18.6 \text{ m s}^{-1}$ . The mass of the ball is  $46.5 \text{ g}$ .

(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]

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

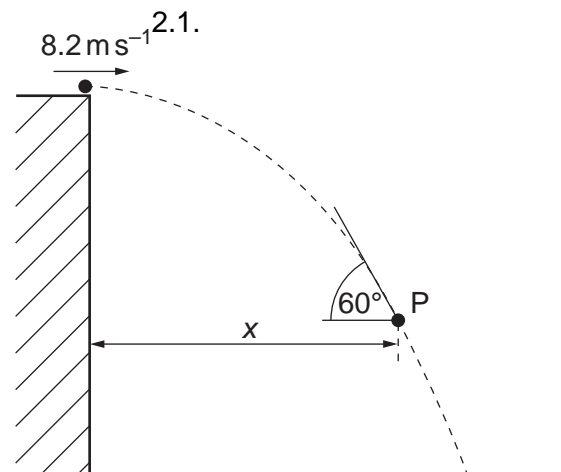


Fig. 2.1

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  $60^\circ$  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  $x$ .

$x = \dots\dots\dots$  m [2]

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

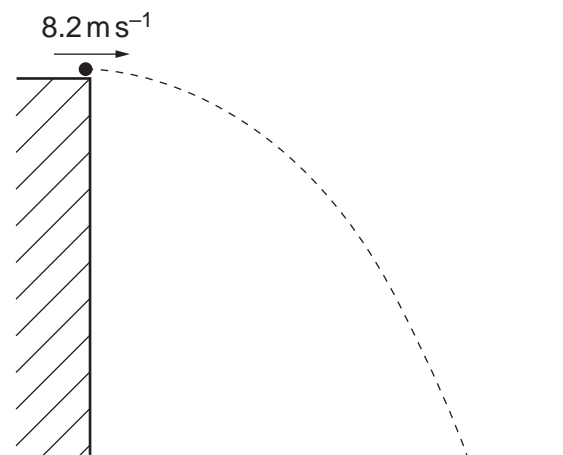


Fig. 2.2

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

- (i) greater than  $8.2 \text{ ms}^{-1}$  and with negligible air resistance (label this path G), [2]
- (ii) equal to  $8.2 \text{ ms}^{-1}$  but with air resistance (label this path A). [2]

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

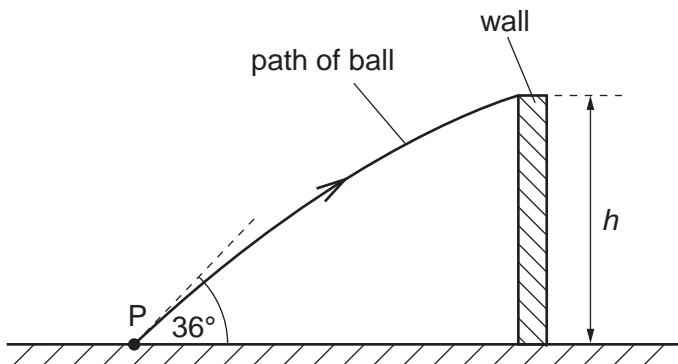


Fig. 2.1

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

$$h = \dots\dots\dots \text{m [3]}$$

(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]