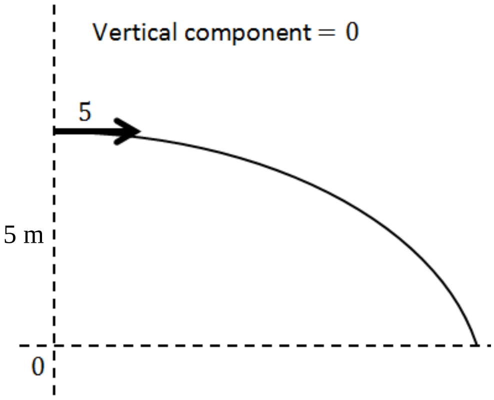
Section 1: Introduction

Solutions to Exercise level 1

1. (i) (a)



(b) $\underset{\sim}{v} = \underset{\sim}{u} + \underset{\sim}{a}t$

$$\underset{\sim}{v} = \begin{pmatrix} 5 \\ 0 \end{pmatrix} + \begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t = \begin{pmatrix} 5 \\ -9.8t \end{pmatrix}$$

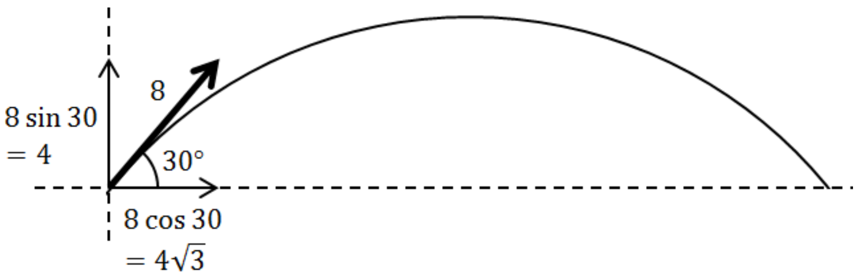
(c) From starting point $\underset{\sim}{s} = \underset{\sim}{u}t + \frac{1}{2}\underset{\sim}{a}t^2$

Using $\underset{\sim}{r}$ for the position of the projectile:

$$\underset{\sim}{r} = \begin{pmatrix} 0 \\ 5 \end{pmatrix} + \begin{pmatrix} 5 \\ 0 \end{pmatrix} t + \tfrac{1}{2} \begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t^2$$

$$= \begin{pmatrix} 5t \\ 5 - 4.9t^2 \end{pmatrix}$$

(ii) (a)



(b) $\underset{\sim}{v} = \underset{\sim}{u} + \underset{\sim}{a}t$

$$\underset{\sim}{v} = \begin{pmatrix} 4\sqrt{3} \\ 4 \end{pmatrix} + \begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t = \begin{pmatrix} 4\sqrt{3} \\ 4 - 9.8t \end{pmatrix}$$

(c) $\underset{\sim}{s} = \underset{\sim}{u}t + \frac{1}{2}\underset{\sim}{a}t^2$

Since it starts at the origin, $\underset{\sim}{s}$ gives the position:

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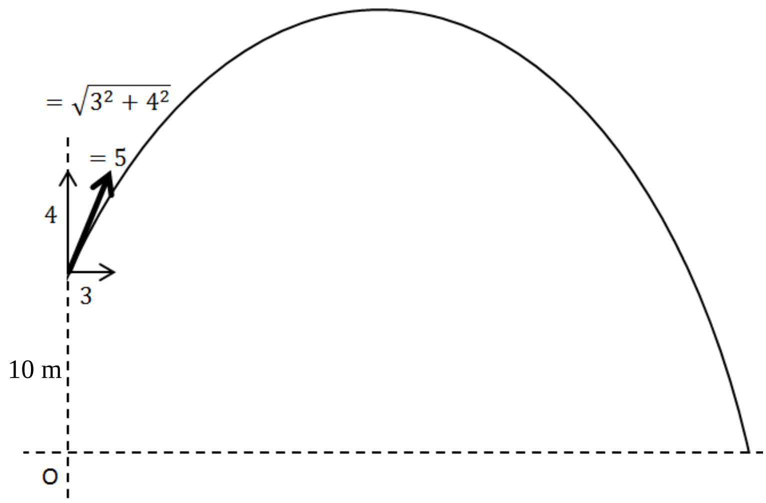
$$\underset{\sim}{s} = \begin{pmatrix} 4\sqrt{3} \\ 4 \end{pmatrix} t + \tfrac{1}{2}\begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t^2$$

$$= \begin{pmatrix} 4\sqrt{3}t \\ 4t - 4.9t^2 \end{pmatrix}$$

(iii) (a)



(b) $\underset{\sim}{v} = \underset{\sim}{u} + \underset{\sim}{a}t$

$$\underset{\sim}{v} = \begin{pmatrix} 3 \\ 4 \end{pmatrix} + \begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t = \begin{pmatrix} 3 \\ 4 - 9.8t \end{pmatrix}$$

(c) From starting point $\underset{\sim}{s} = \underset{\sim}{u}t + \tfrac{1}{2}\underset{\sim}{a}t^2$

Using $\underset{\sim}{r}$ for the position of the projectile:

$$\underset{\sim}{r} = \begin{pmatrix} 0 \\ 10 \end{pmatrix} + \begin{pmatrix} 3 \\ 4 \end{pmatrix} t + \tfrac{1}{2}\begin{pmatrix} 0 \\ -9.8 \end{pmatrix} t^2$$

$$= \begin{pmatrix} 3t \\ 10 + 4t - 4.9t^2 \end{pmatrix}$$

2. (i) (a) Looking at vertical motion: $u = 5\sin 60°, v = 0, a = -9.8, t = ?$

$v = u + at$

$0 = 5\sin 60° - 9.8t$

$$t = \frac{5\sin 60°}{9.8} = 0.442 \text{ s (3 s.f.)}$$

(b) $v^2 = u^2 + 2as$

$0 = (5\sin 60°)^2 - 19.6s$

$$s = \frac{(5\sin 60°)^2}{19.6} = 0.957 \text{ m (3 s.f.)}$$

Maximum height $= 15 + s = 16.0$ m (3 s.f.)

(ii) (a) Looking at vertical motion: $u = 4, v = 0, a = -9.8, t = ?$

$v = u + at$

$0 = 4 - 9.8t$

$t = \frac{4}{9.8} = 0.408 \text{ s (3 s.f.)}$

(b) $v^2 = u^2 + 2as$

$0 = 4^2 - 19.6s$

$s = \frac{16}{19.6} = 0.816 \text{ m (3 s.f.)}$

Maximum height $= 3 + s = 3.82 \text{ m (3 s.f.)}$

3. (i) Looking at vertical motion to calculate the time of flight:

$s = 0, u = 4, a = -9.8, t = ?$

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

$0 = 4t - 4.9t^2$

$t(4.9t - 4) = 0$

$t = 0$ initially or $t = \frac{4}{4.9} = 0.816 \text{ s (3 s.f.)}$

Looking at horizontal motion:

Horizontal velocity is constant, so $s = ut$

$= 3 \times \frac{4}{4.9}$

$= 2.45 \text{ m (3 s.f.)}$

(ii) Looking at vertical motion to calculate the time of flight:

$s = 0, u = 1, a = -9.8, t = ?$

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

$0 = t - 4.9t^2$

$t(4.9t - 1) = 0$

$t = 0$ initially or $t = \frac{1}{4.9} = 0.204 \text{ s (3 s.f.)}$

Looking at horizontal motion:

Horizontal velocity is constant, so $s = ut$

$= 5 \times \frac{1}{4.9}$

$= 1.02 \text{ m (3 s.f.)}$

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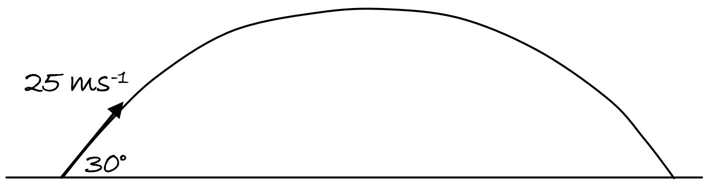
4. (i)



(ii) $u_x = 25\cos 30° = 12.5\sqrt{3}$

$u_y = 25\sin 30° = 12.5$

(iii) $v_x = 12.5\sqrt{3}$ (horizontal speed is constant)

$v_y = u_y - gt$

$= 12.5 - 9.8t$

(iv) $x = u_x t$

$= 12.5\sqrt{3}t$

$y = u_y t - \frac{1}{2}gt^2$

$= 12.5t - 4.9t^2$

5. (i) At maximum height $v_y = 0$

Vertically: $v_y^2 = u_y^2 - 2gh$

$0 = 12.5^2 - 2 \times 9.8h$

$h = \frac{12.5^2}{19.6} = 7.97$

Greatest height reached = 7.97 m.

(ii) The particle hits the ground when $y = 0$:

Vertically: $y = 12.5t - 4.9t^2$

$0 = t(12.5 - 4.9t)$

$t = 0$ or $t = \frac{12.5}{4.9}$

Time taken = 2.55 seconds.

(iii) Range = horizontal distance covered during time of flight

Horizontally: $x = 12.5\sqrt{3}t$

$= 12.5\sqrt{3} \times \frac{12.5}{4.9}$

$= 55.2$

Horizontal range = 55.2 m.