# Section 1: Introduction

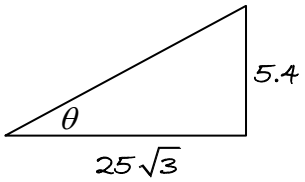
## Solutions to Exercise level 2

1. (i) Horizontally: $v_x = 50\cos 30° = 25\sqrt{3}$

Vertically: $v_y = u + at$

$= 50\sin 30° - 9.8 \times 2$

$= 5.4$




Speed $= \sqrt{(25\sqrt{3})^2 + 5.4^2} = 43.6\ \text{ms}^{-1}$ (3 s.f.)

$\tan\theta = \dfrac{5.4}{25\sqrt{3}}$

$\theta = 7.1°$

The velocity is 43.6 $\text{ms}^{-1}$ at an angle of 7.1° above the horizontal.

(ii) At greatest height, $v_y = 0$

Vertically: $0 = 50\sin 30° - 9.8t$

$t = \dfrac{25}{9.8}$

The time taken to reach the greatest height is 2.55 seconds (3 s.f.)

(iii) Vertically: $y = 50t\sin 30° - \frac{1}{2}gt^2$

$= 25 \times \dfrac{25}{9.8} - \dfrac{9.8}{2}\left(\dfrac{25}{9.8}\right)^2$

$= 31.9$

The greatest height reached = 31.9 m (3 s.f.)

2. (i) Vertically: $s = -50$, $g = -9.8$, $u = 0$, $t = ?$

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

$-50 = 0 + \frac{1}{2} \times -9.8t^2$

$t^2 = \dfrac{50}{4.9}$

$t = 3.19$

The time in the air is 3.19 seconds (3 s.f.)

(ii) Horizontally: $x = ut$

$$65 = u\sqrt{\frac{50}{4.9}}$$

$$u = 20.3$$

The initial speed is 20.3 $ms^{-1}$.

3. Vertically: $s = -19.6$, $g = -9.8$, $u = 0$, $t = ?$

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

$-19.6 = 0 + \frac{1}{2} \times -9.8t^2$

$t^2 = 4$

$t = 2$

It hits the ground after 2 seconds.

Horizontally: $x = ut$

$= 24.5 \times 2$

$= 49$

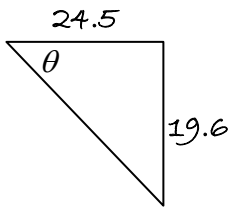
Range = 49 m.

When the ball hits ground:

Horizontally: $v_x = 24.5$

Vertically: $v_y = 0 - 9.8 \times 2$

$v_y = -19.6$



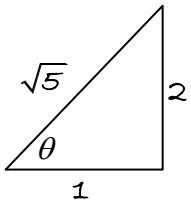

Speed $= \sqrt{24.5^2 + 19.6^2} = 31.4$ $ms^{-1}$ (3 s.f.).

$\tan\theta = \frac{19.6}{24.5}$

$\theta = 38.7°$

The velocity is 31.4 $ms^{-2}$ at an angle 38.7 below the horizontal.

4. (i)




$\tan\theta = 2$ $\sin\theta = \frac{2}{\sqrt{5}}$ $\cos\theta = \frac{1}{\sqrt{5}}$

Horizontally: $u_x = 45\cos\theta = 45 \times \frac{1}{\sqrt{5}} = 9\sqrt{5}$ $ms^{-1}$

Vertically: $u_y = 45\sin\theta = 45 \times \frac{2}{\sqrt{5}} = 18\sqrt{5}$ $ms^{-1}$

(ii) Horizontally: $v_x = 9\sqrt{5}$ since horizontal velocity is constant

Vertically: $v_y = u_y + at$

$= 18\sqrt{5} - 9.8t$

(iii) Horizontally: $x = u_x t = 9\sqrt{5}t$

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

$= 18\sqrt{5}t - 4.9t^2$

(iv) Time of flight is the time at which $y = 0$

Vertically: $0 = 18\sqrt{5}t - 4.9t^2$

$0 = t(18\sqrt{5} - 4.9t)$

$t = 0$ or $t = \dfrac{18\sqrt{5}}{4.9}$

Time of flight = 8.21 seconds (3 s.f.)

Horizontally: $x = 9\sqrt{5}t$

$x = 9\sqrt{5} \times \dfrac{18\sqrt{5}}{4.9} = 165$

The range is 165 m (3 s.f.)

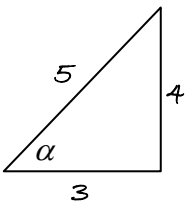
(v) At greatest height, $v_y = 0$

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

$0 = (18\sqrt{5})^2 - 2 \times 9.8h$

$h = \dfrac{1620}{19.6} = 82.7$

5. (i)




$\tan\alpha = \frac{4}{3}$ $\sin\alpha = \frac{4}{5}$ $\cos\alpha = \frac{3}{5}$

Horizontally: $u_x = 30\cos\alpha = 30 \times \frac{3}{5} = 18$

Vertically: $u_y = 30\sin\alpha = 30 \times \frac{4}{5} = 24$

(ii) At maximum height, $v_y = 0$

Vertically: $v_y = u_y + at$

$0 = 24 - 9.8t$

$t = \dfrac{24}{9.8}$

Time taken to reach highest point = 2.45 seconds (3 s.f.)

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

$0 = 24^2 - 2 \times 9.8h$

$h = \frac{576}{19.6} = 29.4$

Maximum height = 29.4 m (3 s.f.).

(iii) Time of flight is twice the time taken to reach highest point

Time of flight $= \frac{48}{9.8} = 4.90$ seconds (3 s.f.)

Horizontally: $x = 18t = 18 \times \frac{48}{9.8} = 88.2$

The range is 88.2 m (3 s.f.)

6. Horizontally: $x = 20t$

When ball reaches net, $x = 12$, so $12 = 20t \Rightarrow t = 0.6$

Vertically when ball reaches net: $y = 0 - \frac{1}{2}gt^2 = -4.9 \times 0.6^2 = -1.764$

The ball has dropped by 1.764 m, so its height is 2.8 – 1.764 = 1.036

The net is 1 m high, so the ball clears the net by 3.6 cm.