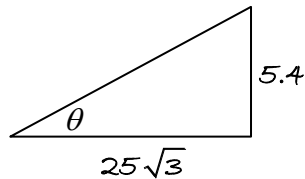


Section 1: Introduction

Solutions to Exercise level 2

1. (i) Horizontally: $v_x = 50 \cos 30^\circ = 25\sqrt{3}$
 Vertically: $v_y = u + at$
 $= 50 \sin 30^\circ - 9.8 \times 2$
 $= 5.4$



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

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

$\theta = 7.1^\circ$

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

(ii) At greatest height, $v_y = 0$
 Vertically: $0 = 50 \sin 30^\circ - 9.8t$

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

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

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

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

$= 31.9$

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

2. (i) Vertically: $s = -50$ $s = ut + \frac{1}{2}at^2$
 $g = -9.8$ $-50 = 0 + \frac{1}{2} \times -9.8t^2$
 $u = 0$ $t^2 = \frac{50}{4.9}$
 $t = ?$ $t = 3.19$

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

MEI A level Maths Projectiles 1 Exercise solutions

(ii) Horizontally: $x = ut$

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

$$u = 20.3$$

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

3. Vertically: $s = -19.6$ $s = ut + \frac{1}{2}at^2$
 $g = -9.8$ $-19.6 = 0 + \frac{1}{2} \times -9.8t^2$
 $u = 0$ $t^2 = 4$
 $t = ?$ $t = 2$

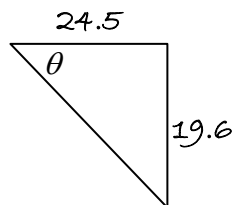
It hits the ground after 2 seconds.

Horizontally: $x = ut$
 $= 24.5 \times 2$
 $= 49$

Range = 49 m.

When the ball hits ground:

Horizontally: $v_x = 24.5$
 Vertically: $v_y = 0 - 9.8 \times 2$
 $v_y = -19.6$



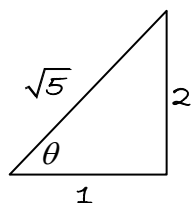
$$\text{Speed} = \sqrt{24.5^2 + 19.6^2} = 31.4 \text{ ms}^{-1} \text{ (3 s.f.)}$$

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

$$\theta = 38.7^\circ$$

The velocity is 31.4 ms^{-1} at an angle 38.7° below the horizontal.

4. (i)



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

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

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

MEI A level Maths Projectiles 1 Exercise solutions

(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 $t = \frac{18\sqrt{5}}{4.9}$

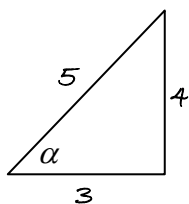
Time of flight = 8.21 seconds (3 s.f.)

Horizontally: $x = 9\sqrt{5}t$
 $x = 9\sqrt{5} \times \frac{18\sqrt{5}}{4.9} = 165$

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

(v) At greatest height, $v_y = 0$
Vertically: $v_y^2 = u_y^2 - 2gh$
 $0 = (18\sqrt{5})^2 - 2 \times 9.8h$
 $h = \frac{1620}{19.6} = 82.7$

5. (i)



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

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: $v_y = u_y + at$
 $0 = 24 - 9.8t$
 $t = \frac{24}{9.8}$

MEI A level Maths Projectiles 1 Exercise solutions

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

$$\text{Vertically: } v_y^2 = u_y^2 - 2gh$$

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

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

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

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

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

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

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.