

Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

7 Projectiles

Exercise A, Question 1

Question:

A rugby ball is kicked from ground level so that its initial velocity is 18 m s^{-1} and at an angle of 45° above the horizontal. Find:

- (a) the time of flight,
- (b) the range,
- (c) the maximum height of the ball.

Solution:

$$x = v \cos \theta t \quad \Rightarrow \quad x = 18 \cos 45^\circ t$$

$$(a) \quad y = v \sin \theta t - \frac{1}{2}gt^2 \quad \Rightarrow \quad y = 18 \sin 45^\circ t - \frac{1}{2}gt^2$$

$$\text{For time of flight, } y = 0 \quad \Rightarrow \quad 18 \sin 45^\circ t - \frac{1}{2}gt^2 = 0$$

$$t = 0 \text{ (not required) or } t = \frac{18 \sin 45^\circ}{\frac{1}{2}g}$$

$$= 2.60 \text{ s}$$

$$(b) \quad \text{Range, } x, \text{ is } 18 \cos 45^\circ \times 2.60$$

$$= 33.1 \text{ m}$$

(c) At maximum height, vertical component of velocity is zero

$$\therefore v = u + at \quad \Rightarrow \quad 0 = 18 \sin 45^\circ - gt$$

$$t = 1.30 \text{ sec}$$

$$\text{Maximum height, } y = 18 \sin 45^\circ \times 1.30 - \frac{1}{2}g(1.30)^2$$

$$= 8.27 \text{ m .}$$

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Exercise Test yourself, Question 2

Question:

A bullet is fired horizontally at a speed of 100 m s^{-1} from a height of 3 m.

- (a) Find the time when the bullet hits the ground.
 (b) Find the horizontal distance travelled by the bullet.

Solution:

- (a) Position of bullet relative to the point of firing is given by

$$x = 100t$$

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

The bullet hits the ground when $y = -3$,

$$\therefore -3 = -\frac{1}{2}gt^2$$

$$t = \sqrt{\frac{6}{g}} = 0.7824 \text{ s}$$

Time is 0.782 s

- (b) Horizontal distance, x is 100×0.782
 $= 78.2 \text{ m}$

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Exercise Test yourself, Question 3

Question:

A ball is thrown from a height of 1.5 m at a speed of 12 m s^{-1} and at an angle of 20° above the horizontal. It hits the ground for the first time T seconds after it was thrown.

- (a) Find T .
- (b) Find the horizontal distance travelled by the ball.
- (c) Find the speed of the ball when it hits the ground.

Solution:

(a) Position of the ball relative to the point of throwing is given by

$$x = 12 \cos 20^\circ t$$

$$y = 12 \sin 20^\circ t - \frac{1}{2}gt^2$$

Ball hits the ground when $y = -1.5$,

$$-1.5 = 12 \sin 20^\circ t - \frac{1}{2}gt^2$$

$$4.9t^2 - 4.104t - 1.5 = 0$$

$$t = \frac{4.104 \pm \sqrt{4.104^2 + 4 \times 4.9 \times 1.5}}{2 \times 4.9}$$

$$= 1.112 \text{ s (negative value not required)}$$

$$\therefore T = 1.11 \text{ s}$$

(b) Horizontal distance, $x = 12 \cos 20^\circ \times 1.112$
 $= 12.54 \text{ m}$

\therefore Horizontal distance is 12.5 m

Horizontal speed is $12 \cos 20^\circ = 11.276$

For the vertical speed, using $v = u + at$ gives

(c) $v = 12 \sin 20^\circ - g \times 1.112$
 $= -6.793$

\therefore speed of ball is $\sqrt{11.276^2 + (-6.793)^2}$
 $= 13.16$

\therefore Speed is 13.2 m s^{-1} .