

Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

7 Projectiles

Exercise A, Question 6

Question:

A ball is thrown with a speed of 12 m s^{-1} at an angle of 30° to the horizontal. It is initially at ground level.

(a) Find the time of flight, the maximum height to which the ball rises and the range.

(b) Find also the speed and direction of flight of the ball after 0.5 s and 1.0 s.

Solution:

(a) The equations of motion of a projectile give

$$\begin{aligned}x &= 12 \cos 30^\circ t \\y &= 12 \sin 30^\circ t - \frac{1}{2}gt^2\end{aligned}$$

$$\text{For the time of flight, } y = 0 \Rightarrow t = \frac{12 \sin 30^\circ}{\frac{1}{2}g} \text{ or } 0 \text{ (not required)}$$

$$\therefore t = 1.22 \text{ s}$$

To find the maximum height,

use $v^2 = u^2 + 2as$ vertically

$$0 = (12 \sin 30^\circ)^2 - 2gs$$

$$\begin{aligned}s &= \frac{(12 \sin 30^\circ)^2}{2g} \\&= 1.84 \text{ m}\end{aligned}$$

The range, x at the time of flight, is $12 \cos 30^\circ \times 1.22 = 12.7 \text{ m}$

(b) After 0.5 sec, the horizontal speed is $12 \cos 30^\circ = 10.392 \text{ m s}^{-1}$

Using $v = u + at$, the vertical speed is $12 \sin 30^\circ - g \times \frac{1}{2} = 1.1 \text{ m s}^{-1}$

Speed is $\sqrt{10.392^2 + 1.1^2} = 10.45005$

Speed is 10.5 m s^{-1}

$$\tan \theta = \frac{1.1}{10.392}$$

$$\theta = 6.04$$

i.e. speed is 10.5 m s^{-1} at an angle 6.04° above horizontal.



After 1 sec, horizontal speed is $12 \cos 30^\circ = 10.392 \text{ m s}^{-1}$

vertical speed ($v = u + at$) is $12 \sin 30^\circ - g \times 1 = -3.8 \text{ m s}^{-1}$

$$\therefore \text{Speed is } \sqrt{10.392^2 + 3.8^2} \\ = 11.06$$

$$\therefore \text{Speed is } 11.1 \text{ m s}^{-1}$$

$$\tan \theta = \frac{3.8}{10.392}$$

$$\Rightarrow \theta = 20.08^\circ$$

\therefore Speed is 11.1 m s^{-1} at 20.1° below the horizontal.

