

# Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

## 7 Projectiles

### Exercise B, Question 15

#### Question:

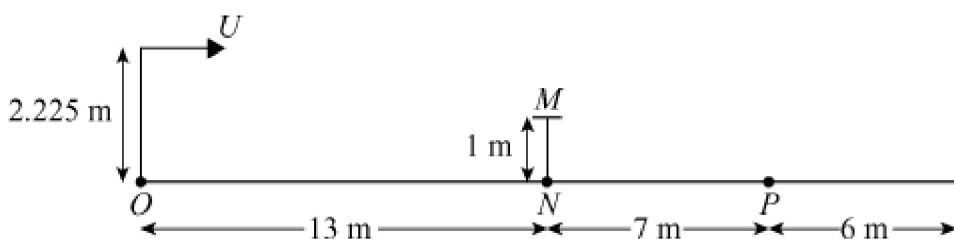
The diagram shows a cross-section of a court where Oliver is practising tennis shots. The court is of length 26 metres, and the net, situated at  $N$ , the centre of the court, is of height 1 metre. Oliver stands at the point  $O$  at one end of the court and serves the ball from a height of 2.225 metres above  $O$  with a horizontal velocity  $U \text{ m s}^{-1}$ .

(a) When  $U = u_1$ , the ball strikes point  $M$ , at the top of the net.

(i) By considering the vertical component of the motion of the ball, show that the time taken for the ball to reach  $M$  is 0.5 seconds.

(ii) Hence, find the value of  $u_1$ .

(b) When  $U = u_2$ , where  $u_2 > u_1$ , the ball first hits the court between the points  $N$  and  $P$ , where  $NP = 7$  metres. Show that  $u_2 < 30 \text{ m s}^{-1}$ . [A]



#### Solution:

(a) (i) Using  $s = ut + \frac{1}{2}at^2$  vertically,

$$\begin{aligned} -1.225 &= -\frac{1}{2}gt^2 \\ t &= \sqrt{\frac{1.225}{\frac{1}{2}g}} \\ &= 0.5 \text{ s} \end{aligned}$$

$\therefore$  Time taken is 0.5 seconds.

(ii) Horizontal distance is  $u_1 t$  which is 13 m.

$$\therefore 13 = 0.5u_1 \text{ or } u_1 = 26 \text{ m s}^{-1}$$

(b) The ball hits the ground before  $P$ .

Hence, when  $x = 20$ , vertical height is less than  $-2.225$

$$x = 20 \Rightarrow 20 = u_2 t$$

$$\text{when } t = \frac{20}{u_2},$$

$$\text{vertical height is } -\frac{1}{2}g \left( \frac{20}{u_2} \right)^2 < -2.225 \text{ (ball hits the ground)}$$

$$\therefore \frac{200g}{u_2^2} > 2.225$$

$$u_2^2 < \frac{200g}{2.225}$$

$$\therefore u_2 < 29.68$$

$$\text{or } u_2 < 30 \text{ m s}^{-1}.$$