$$\Rightarrow \cos\alpha = \frac{3}{\sqrt{178}} \quad \text{and} \quad \sin\alpha = \frac{13}{\sqrt{178}}$$

$$2u^2 = \frac{9g(1 + \tan^2\alpha)}{3\tan\alpha - 1} = \frac{9g\left(1 + \frac{169}{9}\right)}{13 - 1} = \frac{9g + 169g}{12} = \frac{178g}{12}$$

$$\text{Range} = \frac{2u^2 \sin\alpha\cos\alpha}{g} = \frac{\left(\frac{178g}{12}\right)\left(\frac{13}{\sqrt{178}}\right)\left(\frac{3}{\sqrt{178}}\right)}{g} = \frac{13}{4}\text{ m}$$

Q. 13. $\sin\theta = \frac{3}{5} \quad \Rightarrow \quad \cos\theta = \frac{4}{5}$

$u_x = u\cos\theta = \frac{4u}{5} \qquad u_y = u\sin\theta = \frac{3u}{5}$

$v_x = \frac{4u}{5}$

$v_y = \frac{3u}{5} - gt$

$s_x = \frac{4u}{5}t$

$s_y = \frac{3u}{5}t - \frac{1}{2}gt^2$

$s_x = 240 \quad \text{when} \quad s_y = 90$

$\frac{4u}{5}t = 240$

$\Rightarrow t = \frac{300}{u}$

$$\Rightarrow \frac{3u}{5}\left[\frac{300}{u}\right] - \frac{1}{2}g\left[\frac{9{,}0000}{u^2}\right] = 90$$

$$\Rightarrow 180 - \frac{441{,}000}{u^2} = 90$$

$$\Rightarrow \frac{441{,}000}{u^2} = 90$$

$$\Rightarrow u^2 = 4{,}900$$

$$\Rightarrow u = 70\text{ m/s}$$

Q. 14. (i)

Bullet	**Target**
$v_x = 70\cos\theta$	$v_x = 42\sqrt{2}\cos 45° = 42$
$v_y = 70\sin\theta - gt$	$v_y = 42\sqrt{2}\sin 45° = 42$
$s_x = 70t\cos\theta$	$s_x = 42t$
$s_y = 70t\sin\theta - \frac{1}{2}gt^2$	$s_y = 42t + 10$

If bullet is to hit target, then x-velocities must match

$$\Rightarrow 70\cos\theta = 42 \quad \Rightarrow \quad \cos\theta = \frac{42}{70} = \frac{3}{5} \quad \Rightarrow \quad \tan\theta = \frac{4}{3}$$

(ii) Hits target when y-displacements match

$$\Rightarrow 70t\sin\theta - \frac{1}{2}gt^2 = 42t + 10 \quad \ldots \sin\theta = \frac{4}{5}$$

$$\Rightarrow 70t\left(\frac{4}{5}\right) - \frac{1}{2}gt^2 = 42t + 10$$

$$\Rightarrow 56t - 4.9t^2 = 42t + 10$$

$$\Rightarrow 4.9t^2 - 14t + 10 = 0$$

$$\Rightarrow 49t^2 - 140t + 100 = 0$$

$$\Rightarrow (7t - 10)(7t - 10) = 0$$

$$\Rightarrow t = \frac{10}{7}\text{ seconds}$$

Horizontal distance $= s_x = 42t = 42\left(\frac{10}{7}\right) = 60$ m