

**Topic 19: Exercises on Harder 3 Unit Projectile Motion & S.H.M**

**Level 1, Part 1**

1. A particle is projected with speed  $V$  and angle of elevation  $\alpha$  from a point  $O$  on the edge of a cliff of height  $h$ . When the particle hits the ground its path makes an angle  $\tan^{-1}(2 \tan \alpha)$  with the horizontal. Find the distance from the foot of the cliff to the point where it lands.

$$V \cos \alpha \cdot \left[ \frac{V \sin \alpha + \sqrt{V^2 \sin^2 \alpha + 2gh}}{g} \right]$$

2. A particle is projected from a point  $O$  at time  $t = 0$  with speed  $V$  and angle of elevation  $\alpha$ . It moves under gravity and reaches its horizontal range  $R$  at time  $t = T$ . If the direction of motion of the particle makes an angle  $\beta$  with the horizontal when  $t = \frac{1}{4}T$ , show that  $\tan \beta = \frac{1}{2} \tan \alpha$ .

3.  $A$  and  $B$  are two points on level ground,  $40\text{ m}$  apart. Simultaneously a particle is projected from  $A$  towards  $B$  and another particle is projected from  $B$  towards  $A$ , each with speed  $20\text{ ms}^{-1}$  at an angle of elevation of  $45^\circ$ . Given that the two particles collide, find the time and the height above  $AB$  at which this occurs.

$$\sqrt{2}\text{ s}, (20 - g)\text{ m}$$

4. A particle is projected under gravity horizontally with the speed  $30 \text{ ms}^{-1}$  from a point  $B$   $45 \text{ m}$  vertically above a point  $O$  on horizontal ground. Taking  $g = 10 \text{ ms}^{-2}$ , find the time taken for the particle to reach the ground and the horizontal distance it has then traveled.

3 s; 90 m

5. On a certain day, low water for a harbour occurs at 3.30 *am* and high water at 9.45 *am*, the corresponding depths of water being 5 *m* and 15 *m*. Find the rate at which the level of water is rising or falling when the depth of water is 13 *m*.

0.034 *m min*<sup>-1</sup>

6. The depth of water in a harbour is  $7.2\text{ m}$  at low water and  $13.6\text{ m}$  at high water. On Monday, low water is at  $2.05\text{ pm}$  and high water at  $8.20\text{ pm}$ . The captain of a ship drawing  $12.3\text{ m}$  of water wants to leave harbour as early on Monday afternoon as he can. Find between what times he can leave on Monday.

between  $6.29\text{ pm}$  and  $10.11\text{ pm}$