

Q- A ball is thrown vertically upward from a window at 10 m/s at an angle of  $45^\circ$  to the horizontal. It hits the ground 5.0 s later.

- What is the vertical height of the window from the ground?
- How far from the base of the building does the ball strike the ground?

(a) As the initial velocity of the ball is 10 m/s at angle of  $45^\circ$  to the horizontal, and the acceleration is  $g = 9.8 \text{ m/s}^2$  downwards, we can resolve the initial velocity along horizontal and vertical direction.

The initial horizontal velocity

$$v_{0x} = v_0 \cos 45^\circ$$

And initial vertical velocity will be

$$v_{0y} = v_0 \sin 45^\circ$$

Now considering vertical motion only and taking upward direction as positive, the acceleration due to gravity is downward so negative and thus the vertical displacement is given by the second equation of motion

$$\left[ s = v_0 t + \frac{1}{2} a t^2 \right] \text{ as}$$

$$y = v_{0y} t + \frac{1}{2} g t^2$$

$$\text{Or } y = 10 * \sin 45^\circ * 5.0 + \frac{1}{2} (-9.8)(5.0)^2$$

$$\text{Or } y = 10 * 0.707 * 5.0 - 0.5 * 9.8 * 25 = -87.15 \text{ m}$$

Thus the height of the window from the ground is 87.15 m

(Negative sign shown that the point at which the projectile hits the ground is vertically below the point of projection)

(b)

As there is no component of acceleration in horizontal direction, the horizontal displacement is given by simply

$$x = v_{0x} * t = 10 * \sin 45^\circ * 5.0 = 10 * 0.707 * 5.0 = 35.35 \text{ m}$$

Thus the ball strikes the ground at a distance of 35.35 m.

