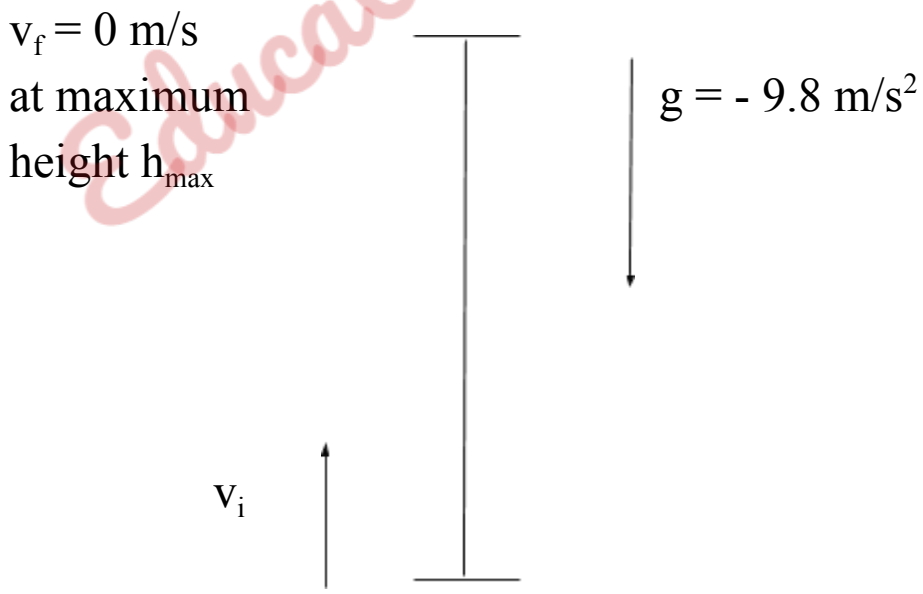
A ball is thrown straight upwards from the ground and reaches a maximum height of 10m before it falls back to the ground. Calculate the total time taken by the ball to rise to maximum height and fall back to the ground.



Given:

Maximum height reached by ball: $h_{max} = 10$m

Acceleration in this case is acceleration due to gravity acting in the downward direction, $g = -9.8$m/s^2

Velocity vector and acceleration vector oppose each other. So the ball keeps slowing down and reaches a velocity of 0 m/s at maximum height and then reverses direction and starts to fall to the ground.

Final velocity at maximum height of the ball is $v_f = 0$ m/s

Determine: total time taken by ball to rise up to maximum height and fall back to the ground: Δt

$$\Delta t = \Delta t_1 + \Delta t_2$$

Δt_1 is time taken by ball to rise up from the ground to the maximum height.
Δt_2 is the time taken by ball to fall from maximum height to the ground.

To find Δt_1, use equation of motion:

$$v_f = v_i + g(\Delta t_1) \text{ ----------(1)}$$

v_i is unknown. To find v_i, use equation of motion:

$$v_f^2 = v_i^2 + 2gh_{max} \text{ ----------(2)}$$

Substituting for v_f, g and h in (2):

$$0^2 = v_i^2 + 2(-9.8)(10)$$
$$-v_i^2 = 2(-9.8)(10)$$
$$v_i = 14 \text{ m/s}$$

Substituting for v_i, v_f and g in (1)

$$0 = 14 + (-9.8)(\Delta t_1)$$

$$\Delta t_1 = -14 / -9.8 = 1.43 \text{ s}$$

Time taken to come down from a given height is the same as the time taken to reach the same height under the influence of gravity .

$$\text{So } \Delta t_1 = \Delta t_2$$

Then total time taken by the ball to rise up from ground to maximum height and fall back to the ground from this height is:

$$\Delta t = \Delta t_1 + \Delta t_2$$

$$\mathbf{\Delta t = 1.43 + 1.43 = 2.9 \text{ s}}$$