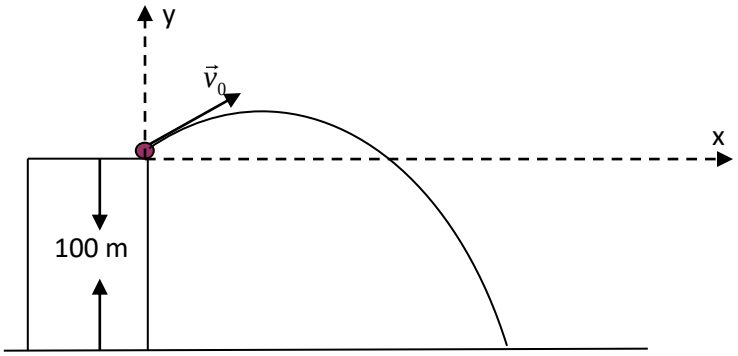
Q- A projectile is fired form the edge of a 100 meter tall building with an initial speed of 10 m/s at 30 degrees above the horizon and lands on the ground. Neglecting the air resistance.



(a) Find the horizontal and vertical components of the initial velocity of the projectile.

The horizontal component of the initial velocity vector will be

$$v_x = v_0 \cos\theta = 10 * \cos 30^0 = 10 * 0.866 = 8.66 \text{ m/s}$$

The vertical component of the initial velocity vector will be

$$v_{0y} = v_0 \sin\theta = 10 * \sin 30^0 = 10 * 0.5 = 5.0 \text{ m/s}$$

(b) How long does it take for the projectile to reach its maximum height?

For the time taken to reach the maximum height we solve for vertical motion only.

Initial vertical velocity $v_{0y} = v_0 \sin\theta$

Final vertical velocity $v_{fy} = 0$

Vertical acceleration $a = -g = -9.8 \text{ m/s}^2$ [upward positive]

Let the time taken is $t_1 = ?$

Using first equation of motion

[v = u + a*t]

$0 = v_o \sin\theta - g*t_1$

Substituting the values, we have

$0 = 10*\sin 30^0 - 9.8*t_1$

Or $0 = 10*0.5 - 9.8\ t_1$

Gives **$t_1 = 5/9.8 = 0.51$ s.**

(c) How long will the projectile be in the air?

For the total time of flight, we can use the vertical motion again.

Initial vertical velocity $v_{0y} = v_0 \sin\theta$

Vertical acceleration a = - g = -9.8 m/s^2

Vertical displacement $y_2 - y_1 = -100 - 0 = -100$ m [y = 0 at the top]

Let the time taken is t_2 =?

Using second equation of motion

$$[s = ut + \frac{1}{2}at^2]$$

$$-100 = 10 * \sin 30^0 * t_2 + 0.5 * 9.8 * t_2^{\ 2}$$

Or $$-100 = 10 * 0.5 * t_2 + 4.9 * t_2^{\ 2}$$

Or $$4.9 * t_2^{\ 2} - 5 * t_2 - 100 = 0.$$

Gives $$t_2 = \frac{5 \pm \sqrt{25 - 4 * 4.9 * (-100)}}{2 * 4.9} = \frac{5 \pm 44.55}{9.8} = 5.06s$$ [negative time is not allowed]

(d) Use your answer in part d to find the range of the projectile, which is the horizontal distance it travels, measure from where it fired from.

Horizontally the projectile moves with constant velocity (zero acceleration) and the time taken to reach ground is t_2, hence the horizontal distance covered x is given by

$x = v_x * t_2$

or $x = v_0 \cos\theta * t_2$

gives $x = 10 * \cos 30^0 * 5.06$

or $x = 10 * 0.866 * 5.06 =$ **43.82 m**