

## Answer on Question 49943, Physics, Mechanics | Kinematics | Dynamics

### Question:

A projectile is shot from the edge of a cliff 125m above ground level with an initial speed of 105 m/s at an angle of  $37^\circ$  with the horizontal.

- 1) Determine the time taken by the projectile to hit point P at ground level.
- 2) Determine the range  $x$  of the projectile as measured from the base of the cliff.
- 3) At the instant just before the projectile hits point P, find the horizontal and vertical components of the velocity.
- 4) The magnitude of the velocity.
- 5) The angle made by the velocity vector with the horizontal.

### Solution:

- 1) Let's write the projections of the initial speed of the projectile on axis  $x$  and  $y$ :

$$v_{0x} = v_0 \cos 37^\circ = 105 \frac{m}{s} \cdot \cos 37^\circ = 83.85 \frac{m}{s},$$

$$v_{0y} = v_0 \sin 37^\circ = 105 \frac{m}{s} \cdot \sin 37^\circ = 63.2 \frac{m}{s}.$$

Let's obtain the time taken by the projectile to hit point P at ground level:

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

$$4.9t^2 + 63.2t - 125 = 0,$$

This equation has two roots:

$$t_1 = \frac{-63.2 - \sqrt{6444.24}}{2 \cdot 4.9} = -14.64,$$

$$t_2 = \frac{-63.2 + \sqrt{6444.24}}{2 \cdot 4.9} = 1.74.$$

Because time can't be negative the correct answer is  $t = 1.74s$ .

- 2) As we know  $t$  we can calculate the range  $x$  of the projectile as measured from the base of the cliff:

$$x = v_{0x}t = 83.85 \frac{m}{s} \cdot 1.74s = 146m$$

3) Now, we find the vertical component of velocity just before the projectile hits point P (we assume that axis  $y$  directed upward from the cliff):

$$v_y = v_{0y} + gt = 63.2 \frac{m}{s} + 9.8 \frac{m}{s^2} \cdot 1.74s = 80.25 \frac{m}{s}.$$

The horizontal and vertical components of the velocity are:  $v_x = 83.85 \frac{m}{s}$ ,  $v_y = 80.25 \frac{m}{s}$ .

4) So, when the projectile hits the ground the velocity components are  $v_x = 83.85 \frac{m}{s}$ ,  $v_y = 80.25 \frac{m}{s}$ . Hence, we can find the magnitude of the velocity:

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{\left(83.85 \frac{m}{s}\right)^2 + \left(80.25 \frac{m}{s}\right)^2} = 116 \frac{m}{s}.$$

5) Finally, we can find the angle made by the velocity vector with the horizontal:

$$\tan \alpha = \frac{v_y}{v_x} = \frac{80.3 \frac{m}{s}}{83.85 \frac{m}{s}} = 0.9576.$$

$$\alpha = \arctan(0.9576) = 43.7^\circ.$$

**Answer:**

1)  $t = 1.74s$ .

2)  $x = 146m$ .

3)  $v_x = 83.85 \frac{m}{s}$ ,  $v_y = 80.25 \frac{m}{s}$ .

4)  $v = 116 \frac{m}{s}$ .

5)  $\alpha = 43.7^\circ$ .