Answer on Question #57854-Physics- Mechanics

You are on the roof of a building that is 150 m tall armed with a tennis ball launcher that fires tennis balls with a speed of 35 m/s. Another building is 100 m away from your building. You are trying to fire a tennis ball into a window of the other building that is 10 m below your current height. Knowing that the ball will fall as it travels you first align the launcher so that it is completely horizontal, hoping that fall the necessary 10 m as it reaches the building

a)how long does it take for the ball to reach the building?

b)Does the ball go through the window?If not where does the ball hit the building?

c)If you want the ball to go through the window at what angles could you aim the launcher?

d)For each angle in (c) find the time for the ball to reach the window

e) Sketch the two trajectories that the ball could take to go through the window. Explain why the times you found in (d) are different?

Solution

a)

$$t = \frac{x}{v_0} = \frac{100\ \mathrm{m}}{35\frac{\mathrm{m}}{\mathrm{s}}} = 2.86\ s\,.$$

b)

$$\Delta y\ =\ \left(\frac{1}{2}\right)gt^2\ =\ \left(\frac{1}{2}\right)(-9.8)(2.86)^2\ =\ -\ 40\ m$$

NO. The ball will not go through the window as it will be 40 m below the starting point and thus 30 m below the window.

c) Equation 1: for vertical travel

$$-\ 10\ =\ 35\sin\alpha\ t\ -\ 4.9t^2$$

Equation 2: for horizontal travel.

$$100 =\ 35\cos\alpha\, t$$

$$t\ = \frac{100m}{35\cos\alpha}$$

Substitute to Equation 1:

$$-\ 10 = \frac{[35 sin\alpha\ (100)]}{35 cos\alpha} - \frac{[\ (4.9)(10000)]}{[(1225\ cos^2\alpha)]}$$

Using

$$\frac{1}{cos^2\alpha} = 1 + \tan^2\alpha$$

$$-\ 10 = 100\tan\alpha\ -40(1+\tan^2\alpha).$$

$$40(1+\tan^2\alpha) - 10 - 100\tan\alpha = 0$$

$$40\tan^2\alpha - 100\tan\alpha + 30 = 0$$

$$D = (-100)^2 - 4\cdot 40\cdot 30 = 5200$$

$$\tan\alpha_1 = \frac{100-\sqrt{5200}}{2\cdot 40} = 0.34861$$

$$\alpha_1 = 19.2^\circ$$

$$\tan\alpha_2 = \frac{100+\sqrt{5200}}{2\cdot 40} = 0.34861$$

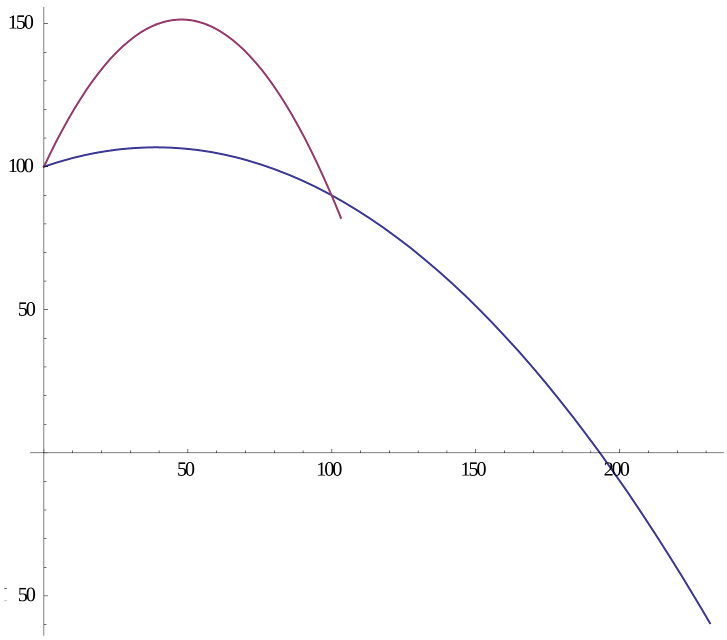
$$\alpha_2 = 65.1^\circ$$

d)

$$t_1 = \frac{x}{v_0\cos\alpha_1} = \frac{100\ \mathrm{m}}{35\frac{\mathrm{m}}{\mathrm{s}}\cos 19.2^\circ} = 3.03\ s\,.$$

$$t_2 = \frac{x}{v_0\cos\alpha_2} = \frac{100\ \mathrm{m}}{35\frac{\mathrm{m}}{\mathrm{s}}\cos 65.1^\circ} = 6.79\ s\,.$$

e)



The point of intersection of two lines is the position of the window.

The times of flight are different because the horizontal displacements are the same but the horizontal speed is dependent on the angle of projection. The formula for time of flight is

$$t = \frac{x}{v_0\cos\alpha}$$