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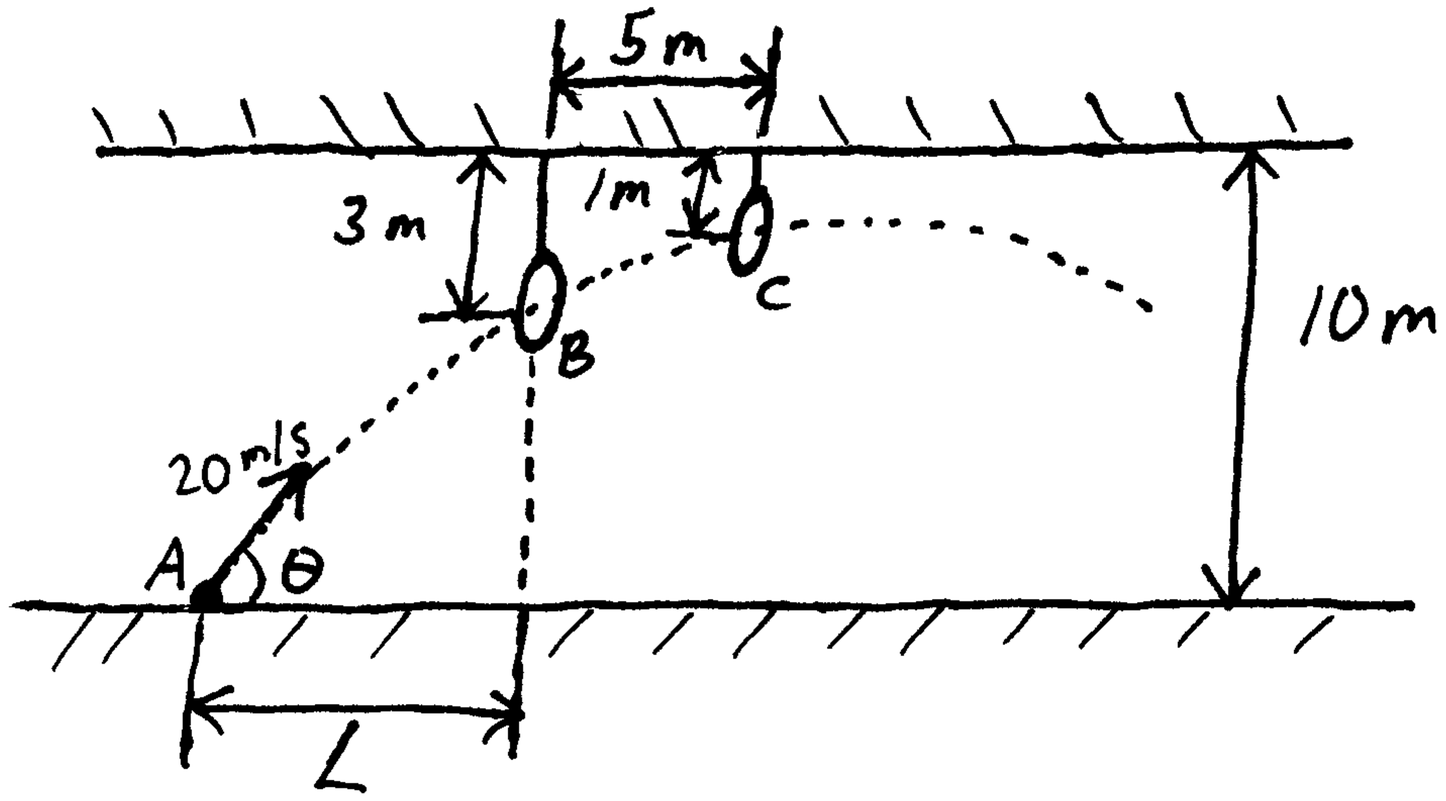
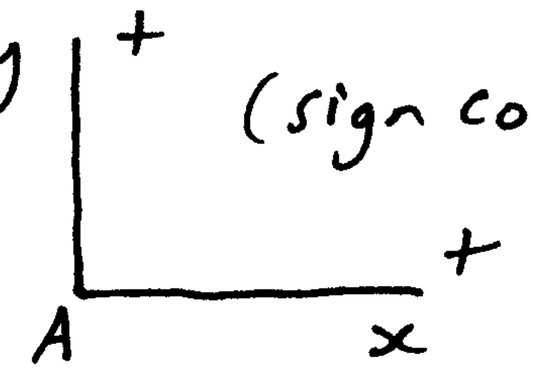
Feb. 4, 2020



In a competition held in a high school gym, the goal is to launch a ball from floor level so that it passes through two rings suspended from the ceiling, as shown. One of the competitors is a physics student who calculates the value of L and θ based on a launch speed of 20 m/s. What are these two values?

Solution: Assumption: - Air resistance is negligible

Set up an xy coordinate frame at the launch point A, as shown:



The path of the ball is parabolic and is given by:

$$y = (\tan\theta)x - \frac{g x^2}{2(v_0 \cos\theta)^2} \quad (1)$$

$g = 9.8\ m/s^2$

$v_0 = 20\ m/s$ (magnitude of initial ball velocity)

At point B, $x = L$, and $y = 10 - 3 = 7m$ (first ring position)

Substitute this into equation (1):

$$7 = (\tan\theta)L - \frac{gL^2}{2(V_0\cos\theta)^2}$$

$$\Rightarrow 7 = (\tan\theta)L - \frac{4.9L^2}{(20\cos\theta)^2} \quad (2)$$

At point C, $x = L+5$, and $y = 10 - 1 = 9\ m$ (second ring position)

Substitute this into equation (1):

$$9 = (\tan\theta)(L+5) - \frac{g(L+5)^2}{2(V_0\cos\theta)^2}$$

$$\Rightarrow 9 = (\tan\theta)(L+5) - \frac{4.9(L+5)^2}{(20\cos\theta)^2} \quad (3)$$

The easiest way to solve equations (2) and (3), for the values of L and θ, is with a computer or programmable calculator.

Solving, $\theta = 44°$, $L = 9.4\ m$ (answer)