A shot putter throws the shot (mass=7.3 kg) with an initial speed of 14.4 m/s at a 34.0 degree angle to the horizontal. Calculate the horizontal distance traveled by the shot if it leaves the athlete's hand at a height of 2.1 m above the ground.

Given:
\[ m = 7.3 \text{ kg} \]
\[ v_0 = 14.4 \frac{m}{s} \]
\[ \theta = 34^\circ \]
\[ h = 2.1 \text{ m} \]

Find:
\[ L = ? \]

**Solution.**

The horizontal velocity is:
\[ v_x = v_0 \cos \theta \]

The vertical velocity is:
\[ v_y = v_0 \sin \theta \]
We can find the time of travel, if we consider the vertical motion. By definition the displacement is:

\[ y = y_0 + vt + \frac{at^2}{2} \]

For the vertical motion in our case:

\[ y_0 = h \]
\[ v = v_y = v_0 \sin \theta \]
\[ a = -g = -9.8 \text{ m/s}^2 \]

So, the time of travel is at \( y = 0 \), therefore:

\[-\frac{g}{2} t^2 + v_0 \sin \theta \ t + h = 0\]

Let solve this quadratic equation:

\[ t = \frac{-v_0 \sin \theta \pm \sqrt{v_0^2 \sin^2 \theta + 2gh}}{-g} \]

Calculate:

\[ t = \frac{-14.4 \cdot 0.56 - \sqrt{(14.4 \cdot 0.56)^2 + 2 \cdot 9.8 \cdot 2.1}}{-9.8} = \frac{-8.05 - \sqrt{105.96}}{-9.8} = \frac{-8.05 - 10.29}{-9.8} = 1.87 \text{ s} \]

We selected the sign “-”, because other answer is negative.

From the horizontal motion we know, that the horizontal distance traveled is:

\[ L = v_x t = v_0 t \cos \theta \]

So,

\[ L = 14.4 \cdot 1.87 \cdot 0.829 = 22.32 \text{ m} \]

Answer.

\[ L = 22.32 \text{ m} \]

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