Two Dimensional Kinematics

Problem 1
A golf ball rolls off a horizontal cliff with an initial speed of 11.4 m/s. The ball falls a vertical distance of 15.5 m into a lake below. (a) How much time does the ball spend in the air? (b) How far from the edge of the cliff does the ball land? (c) What is the speed \( v \) of the ball just before it strikes the water?

\[ Y_0 = 15.5 \text{ m} \]
\[ y = 0 \text{ m} \]
\[ V_{0y} = 0 \text{ m/s} \]
\[ a_y = -9.8 \text{ m/s}^2 \]
\[ t = 1.78 \text{ s} \]

\( V = \sqrt{V_x^2 + V_y^2} \)

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**Note:** Always start by drawing a brief sketch of the problem and labeling the known information.

\( y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2 \)

\( t = \sqrt{\frac{-2y_0}{a_y}} = \sqrt{\frac{-2(15.5 \text{ m})}{-9.8 \text{ m/s}^2}} \)

\( t = 1.78 \text{ s} \)

**b)** \( x_0 = 0 \text{ m} \)
\[ X - x_0 = V_{0x} t \rightarrow X = V_{0x} t \]
\[ X = (11.4 \text{ m/s})(1.78 \text{ s}) \]
\[ X = 20.3 \text{ m} \]

**c)** Note: to get the speed we need to know \( V_x \) and \( V_y \) at \( t = 1.78 \text{ s} \). The speed is then \( V = \sqrt{V_x^2 + V_y^2} \)

\[ V_x = V_{0x} = 11.4 \text{ m/s} \]
[\( V_{0y} = 0 \text{ m/s} \)]
\[ V_y = ? \]
\[ a_y = -9.8 \text{ m/s}^2 \]
\[ t = 1.78 \text{ s} \]

\( V_y = V_{0y} + a_y t \)
\[ V_y = (-9.8 \text{ m/s}^2)(1.78 \text{ s}) \]
\[ V_y = -17.4 \text{ m/s} \]

\( V = \sqrt{V_x^2 + V_y^2} \)
\[ V = \sqrt{ (11.4 \text{ m/s})^2 + (-17.4 \text{ m/s})^2 } \]
\[ V = 20.8 \text{ m/s} \]
Problem 2
A rocket is fired at a speed of 75.0 m/s from ground level, at an angle of 60.0° above the horizontal. The rocket is fired toward an 11.0 m high wall, which is located 27.0 m away. By how much does the rocket clear the top of the wall?

Note: Always start with a quick sketch of the problem. Be sure to label known and unknown quantities.

Note: The horizontal and vertical motions are independent but connected by time \( t \). In order to find \( y \) when \( x = 27.0 \text{ m} \), we need to find \( t \) when \( x = 27.0 \text{ m} \) and use \( t \) to find \( y \).

\[
V_{0x} = (75.0 \text{ m/s}) \cos 60° = 37.5 \text{ m/s}
\]
\[
V_{0x} t = 27.0 \text{ m}
\]
\[
t = \frac{27.0 \text{ m}}{37.5 \text{ m/s}} = 0.72 \text{ s}
\]

Note: To get \( h \) we can find \( y \) at \( t = 0.72 \text{ s} \) and then subtract the height of the wall (11.0 m).

\[
V_{oy} = (75.0 \text{ m/s}) \sin 60° = 65.0 \text{ m/s}
\]
\[
y(t) = V_{oy} t + \frac{1}{2} a_y t^2
\]
\[
y = (65.0 \text{ m/s})(0.72 \text{ s}) + \frac{1}{2} (-9.8 \text{ m/s}^2)(0.72 \text{ s})^2
\]
\[
y = 44.3 \text{ m}
\]
\[
\text{height above wall } h = 44.3 \text{ m} - 11.0 \text{ m}
\]
\[
h = 33.3 \text{ m}
\]