Answer on Question #44723, Physics, Mechanics | Kinematics | Dynamics

A stone is thrown horizontally a velocity of 20.0 m/s at a height of 40.0 m. Find d range and speed when it strikes the ground?

Solution:

Given:

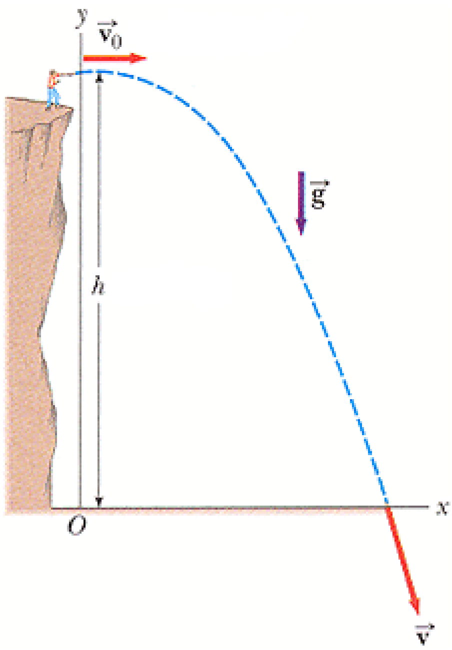
$y_0 = h = 40.0\ \text{m}$,

$v_{0x} = 20.0\ \text{m/s}$,

$v_{0y} = 0\ \text{m/s}$,

$d = ?$

$v = ?$



Projectile motion is a form of motion in which an object or particle (called a projectile) is thrown near the earth's surface, and it moves along a curved path under the action of gravity only.

In projectile motion, the horizontal motion and the vertical motion are independent of each other; that is, neither motion affects the other.

The horizontal component of the velocity of the object remains unchanged throughout the motion. The vertical component of the velocity increases linearly, because the acceleration due to gravity is constant ($g=9.81\ m/s^2$).

Equations related to trajectory motion are given by

$$\text{Horizontal distance,}\quad d = v_{0x}t$$

$$\text{Vertical distance,}\quad y = y_0 + v_{0y}t - \frac{1}{2}gt^2$$

At end of trajectory $y = 0$.

Thus,

$$0 = h + 0 \cdot t - \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

So, the range is

$$d = v_{0x}t = v_{0x}\sqrt{\frac{2h}{g}}$$

$$d = 20 \cdot \sqrt{\frac{2 \cdot 40}{9.81}} = 57.114 \ \approx 57.1 \text{ m}$$

The kinematic equation that describes an object's motion in vertical direction is:

$$v_y^2 = v_{oy}^2 + 2gh$$

Thus,

$$v_y = \sqrt{2gh} = \sqrt{2 \cdot 9.81 \cdot 40.0} = 28 \text{ m/s}$$

The horizontal component of velocity is 20.0 m/s and the vertical component of velocity is 28 m/s.

The final speed is

$$v = \sqrt{v_x^2 + v_y^2}$$

Thus,

$$v = \sqrt{20^2 + 28^2} = 34.4 \text{ m/s}$$

Answer: $d = 57.1 \text{ m}, v = 34.4 \text{ m/s}.$