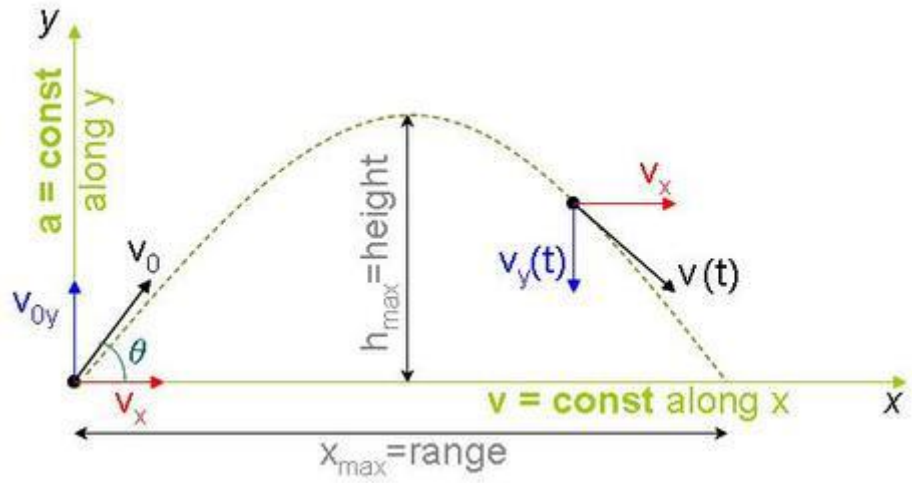
Answer on Question #73195, Physics / Other

Water leaves a fireman's hose (held near the ground) with an initial velocity v_0 = 17.5 m/s at an angle θ = 31.5° above horizontal. Assume the water acts as a projectile that moves without air resistance. Use a Cartesian coordinate system with the origin at the hose nozzle position.

Using v_0, θ, and g, write an expression for the time, t_{max}, the water travels to reach its maximum vertical height.

At what horizontal distance d from the building base, where should the fireman place the hose for the water to reach its maximum height as it strikes the building? Express this distance, d, in terms of v_0, θ, and g.

Solution:



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).

$$v_x = v_0 \cos\theta$$
$$v_{0y} = v_0 \sin\theta$$

To find the time of flight, determine the time the projectile takes to reach maximum height. The time of flight is just double the maximum-height time.

Start with the equation:

$$v_y = v_{0y} + a_y t = v_{0y} - gt$$

At maximum height,

$$v_y = 0$$

The time to reach maximum height is

$$t_{max} = \frac{v_{0y}}{g} = \frac{v_0 \sin\theta}{g}$$

$$t_{max} = \frac{17.5 \sin 31.5°}{9.81} = 0.9321\ s$$

Horizontal distance, $d = v_{0x} t_{max}$

$$d = \frac{v_0 \cos\theta\, v_0 \sin\theta}{g} = \frac{v_0^2 \sin 2\theta}{2g}$$

$$d = \frac{17.5^2 \sin(2 * 31.5°)}{2 * 9.81} = 13.91\ m$$

Answer: $t_{max} = \frac{v_0 \sin\theta}{g}$; $d = \frac{v_0^2 \sin 2\theta}{2g}$