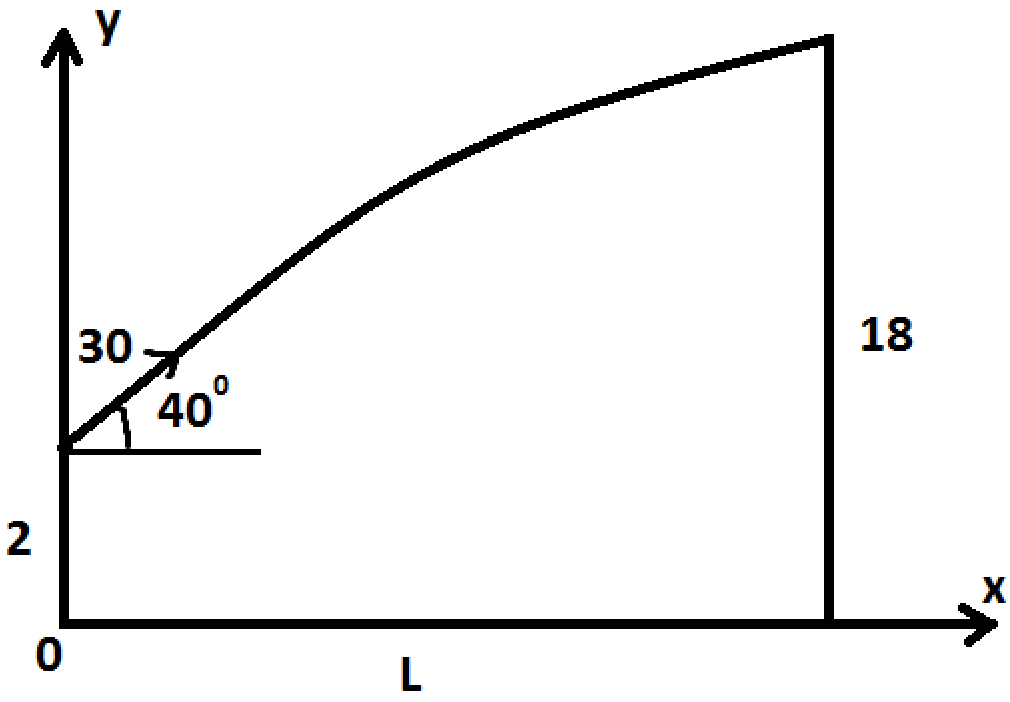
Answer on Question#49708 – Physics – Mechanics | Kinematics | Dynamics

$$L = 30\cos(40°) \times \left(3\sin(40°) - \sqrt{9\sin^2(40°) - \frac{16}{5}}\right) \approx 27.77$$

Solution



Equations of motion:

$$m\frac{d^2x}{dt^2} = 0$$

$$m\frac{d^2y}{dt^2} = -mg$$

Initial conditions:

$$x = 0; \quad V_x(0) = 30\cos(40°)\,; \quad y(0) = 2; \quad V_y(0) = 30\sin(40°)\,;$$

Explicit solutions of the equations above:

$$x = C_1 + C_2 t$$

$$y = -\frac{gt^2}{2} + C_3 t + C_4$$

Use initial conditions:

$$x(0) = C_1 + C_2(0) = C_1 = 0$$

$$V_x(0) = \frac{dx}{dt}(0) = C_2 = 30\cos(40°)$$

$$y(0) = -\frac{g(0)^2}{2} + C_3(0) + C_4 = C_4 = 2$$

$$V_y(0) = \frac{dy}{dt}(0) = -g(0) + C_3 = C_3 = 30\sin(40°)$$

Thus, we have:

$$x(t) = 30\cos(40°)\,t$$

$$y(t) = 2 + 30\sin(40°)\,t - \frac{gt^2}{2}$$

Assume $g = 10$

$$y(t) = 2 + 30\sin(40°)\,t - 5t^2$$

Our aim to define such distance L that at some time t_1: $y(t_1) = 18;\ V_y(t_1) \geq 0$.

$$2 + 30\sin(40°)\,t_1 - 5t_1^2 = 18$$

$$-5t_1^2 + 30\sin(40°)\,t_1 - 16 = 0$$

$$t_1^2 - 6\sin(40°)\,t_1 + \frac{16}{5} = 0$$

$$D = 36\sin^2(40°) - \frac{64}{5}$$

$$t_1(\downarrow) = \frac{6\sin(40°) + \sqrt{36\sin^2(40°) - \frac{64}{5}}}{2} = 3\sin(40°) + \sqrt{9\sin^2(40°) - \frac{16}{5}}$$

$$t_1(\uparrow) = 3\sin(40°) - \sqrt{9\sin^2(40°) - \frac{16}{5}}$$

Obviously, $t_1(\uparrow)$ refer to upward trajectory, $t_1(\downarrow)$ – downward trajectory.

Determine $L = x(t_1)$

$$L = 30\cos(40°) \times \left(3\sin(40°) - \sqrt{9\sin^2(40°) - \frac{16}{5}}\right) \approx 27.77$$