Answer on Question #44205, Physics, Mechanics | Kinematics | Dynamics

A ball thrown horizontally from a point 100 m above the ground with a speed of 20m/s. Find (a) the time it takes to reach the ground, (b) the horizontal distance it travels before reaching the ground, (c) the velocity (direction and magnitude) with which it strikes the ground.

Solution:

$\mathrm{V} = 20\frac{\mathrm{m}}{\mathrm{s}} -$ initial speed of the ball;

$\mathrm{h} = 100\mathrm{m} -$ initial height;

S –Horizontal distance the ball travels before reaching the ground

Equations of motion along the Y-axis

$$\mathrm{h} = \frac{g\mathrm{t}^2}{2},$$

Time taken to reach the ground:

$$\mathrm{t} = \sqrt{\frac{2\mathrm{h}}{\mathrm{g}}} = \sqrt{\frac{2 \cdot 100\ \mathrm{m}}{9.8\frac{\mathrm{m}}{\mathrm{s}^2}}} = 4.5\ \mathrm{sec}$$

Equation of motion of the ball along the X-axis

$$\mathrm{S} = \mathrm{Vt},$$

Horizontal distance the ball travels before reaching the ground

$$\mathrm{S} = \mathrm{Vt} = 20\frac{\mathrm{m}}{\mathrm{s}} \cdot 4.5\ \mathrm{s} = 90\ \mathrm{m}$$

Now that we know the time, we can solve for the horizontal and vertical speeds. There was no horizontal acceleration, so the horizontal component of the speed is constant:

$$\mathrm{V_x} = \mathrm{V} = 20\frac{\mathrm{m}}{\mathrm{s}}$$

Rate equation for the vertical component of the speed:

$$\mathrm{V_y} = \mathrm{gt} = 9.8\frac{\mathrm{m}}{\mathrm{s}^2} \cdot 4.5\ \mathrm{s} = 44\frac{\mathrm{m}}{\mathrm{s}}$$

Now we can use Pythagorean formula to solve for total speed in diagonal direction:

$$\mathrm{V_{final}} = \sqrt{\mathrm{V_x^2} + \mathrm{V_y^2}} = \sqrt{\left(20\frac{\mathrm{m}}{\mathrm{s}}\right)^2 + \left(44\frac{\mathrm{m}}{\mathrm{s}}\right)^2} = 48.3\frac{\mathrm{m}}{\mathrm{s}}$$

Direction of the final velocity ($\alpha -$ angle of the final velocity with horizontal)

$$\tan\alpha = \frac{\mathrm{V_y}}{\mathrm{V_x}} \Longrightarrow \alpha = \arctan\left(\frac{\mathrm{V_y}}{\mathrm{V_x}}\right) = \arctan\left(\frac{44\frac{\mathrm{m}}{\mathrm{s}}}{20\frac{\mathrm{m}}{\mathrm{s}}}\right) = 66°$$

Answer: a) $4.5\ \mathrm{sec}$

b) $90\ \mathrm{m}$

c) $48.3\frac{\mathrm{m}}{\mathrm{s}};\ 66°$