Physics 210: Unquiz 01

A ball is thrown upward from an initial position of

$$\vec{R} = 0\hat{x} + 4\hat{y}\,\text{m}$$

with an initial velocity vector given by

$$\vec{v} = 0\hat{x} + 5\hat{y}\,\tfrac{\text{m}}{\text{s}}\,\textbf{.}$$

(1) How high does the ball travel above the coordinate given by:

$$\vec{P} = 0\hat{x} + 0\hat{y}\,\textbf{?}$$

(2) Find the velocity vector when the ball strikes the ground.

(3) How long is the ball in flight?

Physics 210: Unquiz 01 Solution

A ball is thrown upward from an initial position of

$$\vec{R} = 0\hat{x} + 4\hat{y}\,m$$

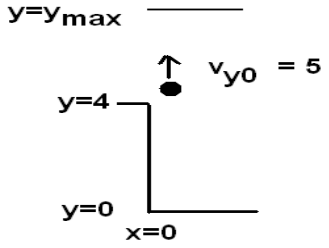
with an initial velocity vector given by

$$\vec{v} = 0\hat{x} + 5\hat{y}\,\tfrac{m}{s}.$$

(1) How high does the ball travel above the coordinate given by:

$$\vec{P} = 0\hat{x} + 0\hat{y}\,?$$

Draw a sketch of the situation.



Use the 3rd. equation of motion here and recognize that this is 1-dimensional motion.

$$v_y^2 = v_{y,0}^2 + 2a_y\Delta y$$

At the top, the y component of the velocity is zero. The acceleration is replaced by:

$$a_y = -g; g = +9.8\,\tfrac{m}{s^2}$$

Substitute and solve for v_y=0:

$$0 = v_{y,0}^2 - 2g\Delta y \Rightarrow \Delta y = \tfrac{v_{y,0}^2}{2g} = \tfrac{5^2}{2x9.8} = 1.28m$$

This is above the ground a distance of 4 m. The total height above the ground is:

h=4+1.28=5.28m

(2) Find the velocity vector when the ball strikes the ground.
Use the 3rd. equation of motion here, recognizing that the total distance the ball falls is 5.28m:

$$v_y^2 = v_{y,0}^2 + 2a_y\Delta y$$

The ball starts with zero initial y velocity at the top. Solve this equation for v_y:

$$v_y^2 = 0 - 2g\Delta y \Rightarrow v_y = \pm\sqrt{-2g\Delta y} = \pm\sqrt{2x9.8x(0-5.28)} = \pm 10.2\,\tfrac{m}{s}$$

The physical solution is the – sign here. So the desired final velocity vector is:

$$\vec{v}_f = 0\hat{x} - 10.2\hat{y}\,\tfrac{m}{s}$$

(3) How long is the ball in flight?
The simplest approach here is to find the time for the ball to rise, then find the time for the ball to fall and add these two times to find the total time. Start with the 2nd equation of motion:

$$v_y = v_{y,0} + a_y t_1 \Rightarrow 0 = 5 - gt_1 \Rightarrow t_1 = \tfrac{5}{9.8} = 0.51s$$

$$v_y = v_{y,0} + a_y t_2 \Rightarrow -10.2 = 0 - gt_2 \Rightarrow t_2 = \tfrac{10.2}{9.8} = 1.04s$$

$$t = t_1 + t_2 = 1.55s$$