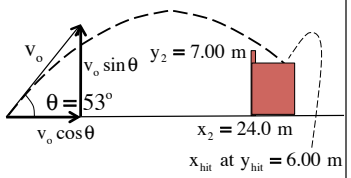
Problem 4.19

This is a good problem as it makes you use the kinematic equations at oddball points.



a.) What's the initial velocity?

We know the time to go 24.0 horizontal meters is 2.20 seconds. Building on this:

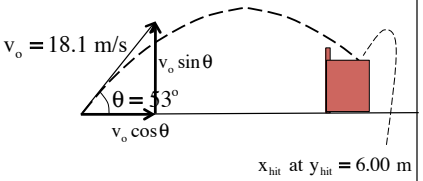
$$x_2 = \cancel{x_1}^{0} + (v_o \cos\theta)\Delta t + \frac{1}{2}\cancel{a_x}^{0}(\Delta t)^2$$
$$\Rightarrow \quad (24.0\text{ m}) = v_o(\cos 53^o)(2.20\text{ s})$$
$$\Rightarrow \quad v_o = 18.1\text{ m/s}$$

b.) As it passes over the wall, it's y-coordinate is:

$$y_{wall} = \cancel{y_1}^{0} + (v_o \sin\theta)\Delta t + \frac{1}{2}(-g)(\Delta t)^2$$
$$\Rightarrow \quad y_{wall} = (18.1\text{ m/s})(\sin 53^o)(2.20\text{ s}) + \frac{1}{2}(-9.80\text{ m/s}^2)(2.20\text{ s})^2$$
$$= 8.13\text{ m}$$

Sooo, the ball clears the 7.00 meter wall by 1.13 meters.

Using the calculated time, the horizontal position when the y-component is 6.00 meters is:

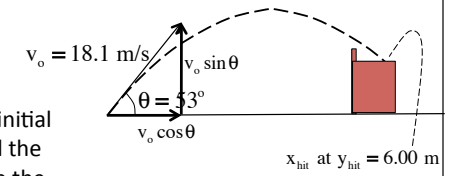


$$x_{hit} = \cancel{x_1}^{0} + (v_o \cos\theta)\Delta t + \frac{1}{2}\cancel{a_x}^{0}(\Delta t)^2$$
$$= (18.1\text{ m/s})(\cos 53^o)(2.45\text{ s})$$
$$\Rightarrow \quad x_2 = 26.7\text{ m}$$

With the wall at 24.0 meters, apparently the ball hits 2.70 meters beyond the wall.

Note: The text's Solution manual listed the answer as 2.78 meters. This is a round-off problem. I'm mentioning it because you may have done the problem the same way they did (it was a canned relationship), and I don't want you confused or confounded because your solution doesn't match mine. I haven't done anything wrong; either way is OK.

c.) How far does it go by touch-down?



This is a classic problem—given the initial velocity and final height, how far did the body go. We need to first determine the time required to get to the point. Using what we know about the y-motion:

$$y_{hit} = \cancel{y_1}^{0} + (v_o \sin\theta)\Delta t + \frac{1}{2}(-g)(\Delta t)^2$$
$$\Rightarrow \quad (6.00\text{ m}) = (18.1\text{ m/s})(\sin 53^o)(\Delta t) + \frac{1}{2}(-9.80\text{ m/s}^2)(\Delta t)^2$$

The quadratic equations yields two time solutions,

$$t_1 = .510\text{ s} \quad \text{and} \quad t_2 = 2.45\text{ s}$$

The first time identifies when the ball first passes through the y = 6.00 meters points. This is on the ball's upswing. The second time identifies when ball hits the roof. That second time is the one we need.