Chapter 3 Problems

1. A baseball is hit into the air at an initial speed of 36.6 m/s and an angle of 50.0° above the horizontal. At the same time, the center fielder starts running away from the batter and catches the ball 0.914 m above the level at which it was hit. If the center fielder is initially 1.10×10^2 m from home plate, what must be his average speed?

Answer: The ball is caught at a vertical displacement of $y = 0.914$ m and a horizontal displacement of $x = v_F t + 1.10 \times 10^2$ m, where v_F is the velocity of the center fielder and t is the time that the ball is in flight. Since the x-component of the ball's velocity does not change during flight, we have that $v_{0x} = v_x$ and therefore $x = v_{0x}t$. We can then write the velocity of the center fielder in terms of the ball's velocity in the x-direction,

$$v_F = v_{0x} - \frac{1.10 \times 10^2\, m}{t}. \tag{1}$$

Since we know the initial velocity in the x-direction, $v_{0x} = v\cos(50.0\,°)$, we must only find the ball's time of flight. This can be found by appealing to the kinematics in the y-direction. From

$$\Delta y = v_{0y}t - \frac{1}{2}gt^2 \tag{2}$$

and

$$v_{0y} = v\sin(50.0°) \tag{3}$$

we have

$$4.90t^2 - 28.0t + 0.914 = 0. \tag{4}$$

Use of the quadratic formula gives $t = 5.68$ s. Plugging this into Eq. 1 yields

$$v_F = 4.2\,\mathrm{m/s}. \tag{5}$$

2. Stones are thrown horizontally with the same velocity from the tops of two different buildings. One stone lands twice as far from the base of the building from which it was thrown as does the other stone. Find the ratio of the height of the taller building to the height of the shorter building.

Answer: The stone thrown from building 1 is in flight for $t_1 = \Delta x_1/v_{0x1}$. The stone thrown from building 2 is in flight for $t_2 = \Delta x_2/v_{0x2}$. Since the initial velocities of both stones are the same, and since stone 1 lands twice as far as stone 2, we have $v_{0x1} = v_{0x2}$ and $\Delta x_1 = 2\Delta x_2$. This allows us to conclude that stone 1 is in the air twice as long as stone 2, or $t_1 = 2t_2$. Furthermore, the heights of the two buildings may be written

$$\begin{aligned} y_1 &= -\frac{1}{2}gt_1^2 \\ y_2 &= -\frac{1}{2}gt_2^2. \end{aligned}$$

Substituting the relation $t_1 = 2t_2$ into the first of the above equations allows one to relate the two heights,

$$y_1 = 4y_2. \tag{6}$$

Building 1 is therefore 4 times taller than building 2.