SAMPLE PROBLEM F

Falling Object

PROBLEM

Jason hits a volleyball so that it moves with an initial velocity of 6.0 m/s straight upward. If the volleyball starts from 2.0 m above the floor, how long will it be in the air before it strikes the floor?

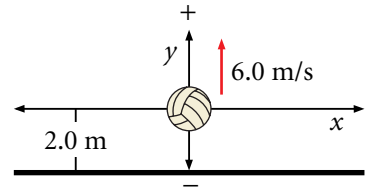
SOLUTION

1. DEFINE

Given: $v_i = +6.0 \text{ m/s} \quad a = -g = -9.81 \text{ m/s}^2$
$\Delta y = -2.0 \text{ m}$

Unknown: $\Delta t = ?$

Diagram: Place the origin at the starting point of the ball ($y_i = 0$ at $t_i = 0$).



2. PLAN

Choose an equation or situation:

Both Δt and v_f are unknown. Therefore, first solve for v_f using the equation that does not require time. Then, the equation for v_f that does involve time can be used to solve for Δt.

$$v_f^2 = v_i^2 + 2a\Delta y \qquad v_f = v_i + a\Delta t$$

Rearrange the equations to isolate the unknown:

Take the square root of the first equation to isolate v_f. The second equation must be rearranged to solve for Δt.

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta y} \qquad \Delta t = \frac{v_f - v_i}{a}$$

3. CALCULATE

Substitute the values into the equations and solve:

First find the velocity of the ball at the moment that it hits the floor.

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta y} = \pm\sqrt{(6.0 \text{ m/s})^2 + 2(-9.81 \text{ m/s}^2)(-2.0 \text{ m})}$$

$$v_f = \pm\sqrt{36 \text{ m}^2/\text{s}^2 + 39 \text{ m}^2/\text{s}^2} = \pm\sqrt{75 \text{ m}^2/\text{s}^2} = -8.7 \text{ m/s}$$

TIP *When you take the square root to find v_f, select the negative answer because the ball will be moving toward the floor, in the negative direction.*

Next, use this value of v_f in the second equation to solve for Δt.

$$\Delta t = \frac{v_f - v_i}{a} = \frac{-8.7 \text{ m/s} - 6.0 \text{ m/s}}{-9.81 \text{ m/s}^2} = \frac{-14.7 \text{ m/s}}{-9.81 \text{ m/s}^2}$$

$$\boxed{\Delta t = 1.50 \text{ s}}$$

4. EVALUATE

The solution, 1.50 s, is a reasonable amount of time for the ball to be in the air.