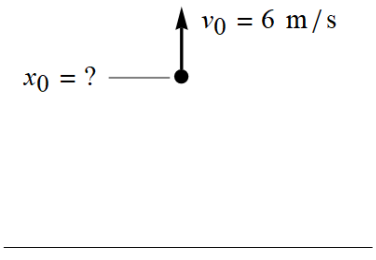
Problem 12-22

A sandbag is dropped from a balloon which is ascending vertically at a constant speed of 6 m/s. If the bag is released with the same upward velocity of 6 m/s when $t = 0$ and hits the ground when $t = 8$ s, determine the speed of the bag as it hits the ground and the altitude of the balloon at this instant.

Solution

Because the acceleration due to gravity is constant, the familiar kinematics formulas can be applied here. Let $x = 0$ be at the ground level, and let x_0 be the height of the sandbag when it's released at $t = 0$.



Use the kinematic formula,

$$x = x_0 + v_0 t + \frac{1}{2}at^2,$$

to determine how high the sandbag is initially, knowing that its final height is 0 after 8 seconds.

$$0 = x_0 + (6)(8) + \frac{1}{2}(-g)(8)^2$$

Solve for x_0.

$$\begin{aligned} x_0 &= 32g - 48 \\ &= 32(9.81) - 48 \\ &\approx 267 \text{ m} \end{aligned}$$

The balloon's velocity is constant at 6 m/s, so its height at $t = 8$ is

$$x = (32g - 48) + 6(8) = 32g \approx 314 \text{ m}.$$

Use the kinematic formula,

$$v = v_0 + at,$$

to determine the sandbag's velocity as it hits the ground.

$$v = 6 + (-g)(8) = 6 - 8g \approx -72.5 \ \frac{\text{m}}{\text{s}}$$

The sandbag's speed as it hits the ground is then 72.5 m/s.