NAME _____ DATE _____ CLASS _____

PB 2-3F

Motion in One Dimension

Problem F

FALLING OBJECT

PROBLEM

When it is completed in 2002, the International Financial Center in Taipei, Taiwan, will be the tallest building in the world. Suppose a construction worker on the top-most floor of the building accidentally knocks a wrench off a ledge. The wrench hits the ground below 9.56 s later. What is the distance between the top-floor of the International Financial Center and the ground. Assume there is no air resistance.

SOLUTION

1. DEFINE

Given: $\Delta t = 9.56$ s

$a = -9.81$ m/s^2

$v_i = 0$ m/s

Unknown: $\Delta x = ?$

2. PLAN

Choose the equation(s) or situation: Displacement is unknown, as is the final velocity. Because time, acceleration, and initial velocity are known, the equation for displacement with constant acceleration can be used.

$$\Delta x = v_i \Delta t + \tfrac{1}{2} a \Delta t^2$$

3. CALCULATE

Substitute the values into the equation(s) and solve:

$$\Delta x = (0 \text{ m/s})(9.56 \text{ S}) + \tfrac{1}{2}(-9.81 \text{ m/s}^2)(9.56 \text{ s})^2$$

$$\Delta x = (0 \text{ m}) + (-448 \text{ m})$$

$$\Delta x = -448 \text{ m}$$

$$\Delta x = \boxed{\text{distance from top of building to ground} = 448 \text{ m}}$$

4. EVALUATE

From the value for Δx the wrench's final speed can be determined as 93.8 m/s, or nearly 340 km/h.

ADDITIONAL PRACTICE

1. Suppose a safety net at one of the floors of the International Financial Center catches the wrench in Problem 2F. The wrench falls into the net with a velocity of 49.5 m/s downward. How far above the ground is the safety net located?
2. A gumdrop is released from rest at the top of the Empire State Building, which is 381 m tall. Disregarding air resistance, calculate the displacement of the gumdrop after 1.00, 2.00, and 3.00 s.
3. A small sandbag is dropped from rest from a hovering hot-air balloon. After 2.0 s, how far below the balloon is the sand bag?

4. A physics student throws a softball straight up into the air with a speed of 17.5 m/s. The ball is in the air for a total of 3.60 s before it is caught at its original position. How high does the ball rise?

5. A surface probe lands on a highland region of the planet Mercury. A few hours later the ground beneath the probe gives way and the probe falls, landing below its original position with a velocity of 11.2 m/s downward. If the free-fall acceleration near Mercury's surface is 3.70 m/s^2 downward, what is the probe's displacement?

6. A ball thrown vertically is caught by the thrower after 5.1 s. Find the maximum height the ball reaches.

7. Find the initial velocity with which the ball in problem 6 is thrown.

8. An archer fires an arrow directly upward, then quickly runs from the launching spot to avoid being struck by the returning arrow. If the arrow's initial velocity is 85.1 m/s upward how long does the archer have to run away before the arrow lands?

9. A popular scene in recent action films shows a character in free-fall speed up to catch a freely falling parachute. Suppose a packed parachute is dropped from rest from an airplane and that a daredevil is launched straight down from the plane 3.00 s later. Neglecting air resistance, the daredevil catches up to the parachute 4.00 s after the daredevil leaves the plane. What are the daredevil's initial and final velocities?

10. The elevators in the Landmark Tower in Yokohama, Japan, are among the fastest in the world. They accelerate upward at 3.125 m/s^2 for 4.00 s to reach their maximum speed. Suppose an empty elevator is moving upward with its maximum speed when the cable breaks, so that the elevator slows down, comes to a stop, and then begins to fall freely. What will the elevator's velocity be 0.00 s, 1.00 s, 2.00 s, and 3.00 s after the cable breaks?