Galileo tried to prove that all falling objects accelerate downward at the same rate. Falling objects do accelerate downward at the same rate in a vacuum. Air resistance, however, can cause objects to fall at different rates in air. Air resistance enables a skydiver's parachute to slow his or her fall. Because of air resistance, falling objects can reach a maximum velocity or *terminal velocity*. In this experiment, you will study the velocities of two different falling objects

OBJECTIVES

In this experiment, you will

- Use a computer-interfaced Motion Detector to measure distance and velocity.
- Produce distance *vs.* time and velocity *vs.* time graphs.
- Analyze and explain the results.

MATERIALS

Computer, Vernier Go!Motion sensor, Logger Lite and Fathom, basket coffee filter, book

PROCEDURE

1. Set up for the experiment.
   a. Open Logger Lite and connect the Go!Motion sensor to the computer.
   b. Logger Lite should recognize the Go!Motion sensor. If it does not, then close the program, reattach the sensor and open Logger Lite again.
   c. The workspace should display three graphs and a table that includes cells for time, distance, velocity, and acceleration.
2. How to conduct the experiment.
   a. In the Experiment Menu select Data Collection. Here you can enter the number of cases to collect and for how long.
   b. One group member will need to hold the Go!Motion sensor at least head high with the sensor facing the ground.
   c. A second group member will need to hold the basket coffee filter with the open side facing up directly below the Go!Motion Sensor.
   d. A third group member will need to select Collect in the tool bar.
   e. When you hear sound coming from the Go!Motion sensor, allow the coffee filter to drop straight down.
   f. Examine the data that is collected. Adjust the number of cases and length of experiment, if necessary. Repeat the coffee-filter drop, if necessary, until you have "smooth" curves.
   g. Once your group has "smooth" curves, we will need to export the data "Coffee Filter Drop".
3. Export/Import data from the experiment.
   a. Now that your data has been collected for time, distance, velocity, and acceleration, we would like to examine the data using *Fathom*. To do this, the data must be exported in a compatible format. Go to the File Menu and select Export As. Choose CSV and save the file using the name "Coffee Filter Drop".
   b. Now the data is ready to import into *Fathom*. Open *Fathom* and under the File Menu select Import. You will see three options. Select Import from File and follow appropriate steps to open the file in the location you saved it to earlier.
   c. Create tables and graphs for distance vs. time, velocity vs. time, and acceleration vs. time.
4. Repeat Steps 2 & 3 for "Book Drop"

WORKING WITH THE DATA

1. Calculate the distance fallen for each object.

2. How do the distances compare? Why do the distances compare this way?

3. Calculate the falling times for each object.

4. How do the falling times compare?

5. Which object fell faster? Why?

6. How are the distance vs. time graphs different? Explain the differences.

7. How are the two velocity *vs*. time graphs different? Explain the differences. Compare the maximum velocities of your two objects. Which object was falling faster when it landed? Why was it falling faster?

8. How are the two acceleration *vs.* time graphs different? Compare the maximum acceleration of your two objects. When did each attain their maximum acceleration? Explain how you know and why it occurs at that particular point.

9. For which object is air resistance more important? Why does air resistance affect this object more than the other object?

10. Which of your velocity *vs.* time graphs would be more like the velocity *vs*. time graph of an object falling in a vacuum? Why?

11. Sketch a velocity *vs*. time curve for an object that is released at 0.5 s, falls with increasing velocity until 1.5 s, falls at constant velocity from 1.5 s to 3.0 s, and lands at 3.0 s. An object that falls at constant velocity is said to have reached *terminal velocity*.

12. Did either of your objects reach terminal velocity? If so, which one?