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 or Fathom, basket coffee filter, book

PROCEDURE

1. Set up for the experiment.
    a. Open Fathom and connect the Go!Motion sensor to the computer. A meter should appear that says "Distance". If it does not appear, select the Meter Menu and choose Motion Detector. The sensor should be clicking and the distance measure should change as you move an object toward and away from the sensor. Pushing the Trigger button will stop the clicking. There will also be a window that opens that will be used to conduct the experiment.
    b. Drag a Collection into the workspace. It will be labeled "Experiment with Distance".
    c. With the Collection selected, drag a Case Table into the workspace.
    d. Drag a Graph into the workspace and add the attributes Time and Distance from the Case Table to the appropriate axes on the graph.
2. How to conduct the experiment.
    a. In the experiment window 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 Start Experiment in the experiment window.
    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 a "smooth" curve.
    g. Once your group has a "smooth: curve, save the workspace as "Coffee Filter Drop".
3. Open a new workspace in Fathom and repeat Step 2 using a book, but save it as "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 could you determine how fast each object was falling at a given time from the distance and time data? Add this as an attribute with the formula to calculate it to each case table. Create a graph comparing this attribute to time for each experiment. Make sure to document you reasoning.

8. 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?

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?