Name ________________________________ Date ________________

Experiment
37

Falling Objects

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 Motion Detector to measure position and velocity.
- Produce position *vs*. time and velocity *vs*. time graphs.
- Analyze and explain the results.

MATERIALS

computer
Vernier computer interface
Motion Detector
ring stand
metal rod
right-angle clamp
basket coffee filter
3 books
meter stick

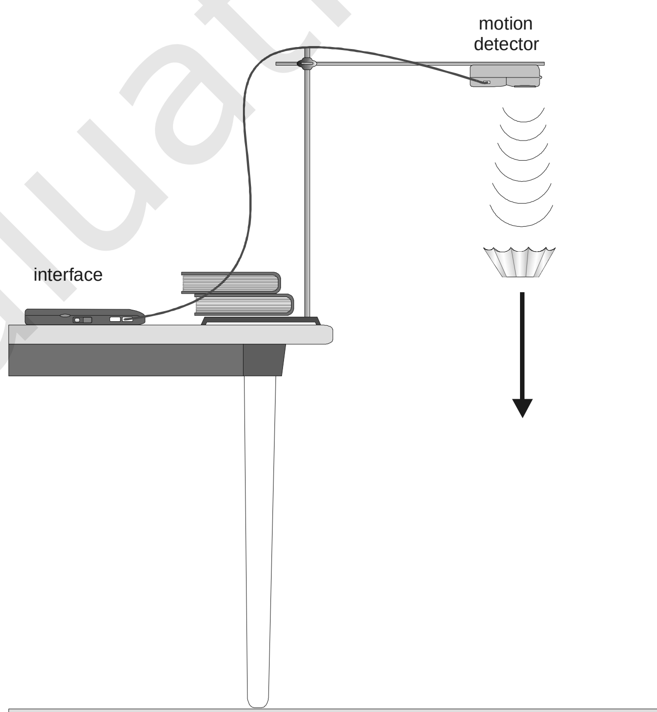

Figure 1

PROCEDURE

1. Set up the apparatus as shown in Figure 1.
   a. Place two books on the base of a ring stand to keep it from falling.
   b. Use a right-angle clamp to fasten a metal rod to the ring stand.
   c. Fasten a Motion Detector under one end of the rod. The Motion Detector should face down and be parallel to the floor.
   d. Move the right-angle clamp, rod, and Motion Detector to the top of the ring stand.
   e. Use a piece of tape to mark a spot on the ring stand that is 50 cm from the right-angle clamp.
   f. Place the ring stand, with the Motion Detector attached, at the edge of your lab table. The Motion Detector must extend 50 cm beyond the table edge.

2. Connect the Motion Detector. If your Motion Detector has a sensitivity switch, set it to Normal.

3. Start the Vernier data-collection program and open the file "37 Falling Objects" from the *Middle School Science with Vernier* folder.

4. Collect data for a falling coffee filter.
   a. Hold a basket coffee filter with the open side facing up at a position of 0.5 m from (at the 0.5 m mark on the ring stand) and directly below the Motion Detector.
   b. Click ▶ Collect to begin data collection.
   c. When you hear sound coming from the Motion Detector, allow the coffee filter to drop straight down.

5. Store data for a good coffee-filter run.
   a. Repeat the coffee-filter drop, if necessary, until you have "smooth" curves for both graphs.
   b. Choose Store Latest Run from the Experiment menu to store your good run. Your coffee-filter run will be stored as Run 1.

6. Repeat Step 4 using a book.
   a. Repeat the book drop, if necessary, until you have "smooth" curves for both graphs.
   b. Do not choose to store this good book run. It will be kept as the Latest Run.

7. Click the Examine button, . The time and position values for both runs will be displayed as the mouse pointer is moved across the graph.

8. Determine and record coffee filter's position data.
   a. Move the mouse pointer to the lowest part of the position *vs*. time graph. Find the position value displayed for the coffee filter in the examine box. This is a measure of the coffee filter's distance from the Motion Detector at the drop point. Record this value in your data table.
   b. Move the mouse pointer to the highest part of the position *vs*. time graph. Find the position value displayed for the coffee filter in the examine box. This is a measure of the coffee filter's distance from the Motion Detector at the landing point. Record this value in your data table.

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9. Determine and record coffee filter's time data.
   a. Move the mouse pointer back to the first part of the curves and determine the time when the coffee filter was dropped. Record this value in your data table.
   b. Move the mouse pointer to the highest part of the position *vs*. time graph. Record the time when the coffee filter landed. Consider both curves as you choose this landing time.

10. Determine the velocity at the highest part of the coffee filter's velocity *vs*. time curve.
    a. Move the mouse pointer to highest point of the coffee filter on the velocity *vs*. time graph. Record the velocity at this point.
    b. Note and record the shape of the curve in the region of the maximum velocity.

11. Repeat Steps 8-10 to determine and record the falling book's data.

12. Print graphs showing the coffee filter and the book results.
    a. Click the Examine button, , to turn off the examine feature.
    b. Print the position *vs*. time and the velocity *vs*. time graphs.
    c. Hand label your graphs with the data you recorded in Steps 8-10.

DATA

	Falling coffee filter		Falling book	
	Position (Y)	Time (X)	Position (Y)	Time (X)
Drop point	m	s	m	s
Landing point	m	s	m	s
Maximum velocity	m/s		m/s	
Curve shape in maximum region				

PROCESSING THE DATA

1. Calculate the distance fallen (in m) for each object. (Subtract the drop-point position from the landing-point position.)

   Falling Coffee Filter   Falling Book

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

3. Calculate the falling time (in s) for each object. (Subtract the drop-point time from the landing-point time.)

Falling Coffee Filter	Falling Book

4. How do the falling times compare?

5. Which object fell faster? Why?

6. How are the two position *vs*. time graphs different? Explain the differences.

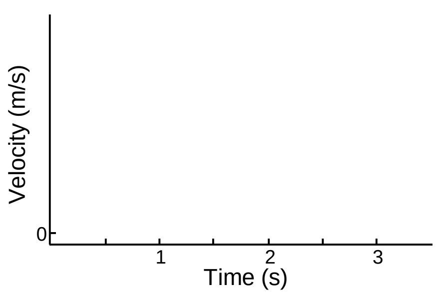
7. How are the two velocity *vs*. time graphs different? Explain the differences.

8. 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.



On the graph to the left, 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? How do you know?

EXTENSIONS

1. Determine the average terminal velocity of a coffee filter in five falls.
2. Study the falling behavior of stacks of 1, 2, 3, 4, and 5 coffee filters.

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Middle School Science with Vernier* lab manual includes 38 labs and essential teacher information. The full lab book is available for purchase at:
http://www.vernier.com/cmat/msv.html

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