


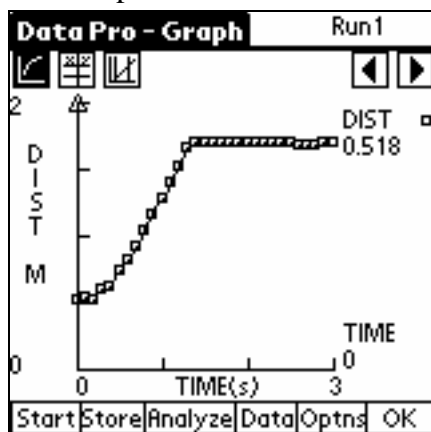


## PROCEDURE

### Part A Falling Coffee Filter

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 Vernier 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 0.5 m 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. Plug the Motion Detector into the DIG/SONIC 1 port of the LabPro interface. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.
3. Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap **(New)** to reset the program.
4. Set up the handheld and interface for data collection.
  - a. On the Main screen, tap **Setup**.
  - b. On the Setup screen, tap **Settings**.
  - c. Enter “0.1” as the time between samples in seconds, using the onscreen keyboard (tap “123”) or using the Graffiti writing area.
  - d. Enter “30” as the number of samples. (Data collection will last 3 seconds.)
  - e. Tap **OK** twice to return to the Main screen.
5. Collect data for a falling coffee filter.
  - a. Hold a basket coffee filter with the open side facing up at a position 0.5 m from (at the 0.5 m mark on the ring stand) and directly below the Motion Detector.
  - b. Tap **Start** to begin data collection.
  - c. When you hear sound coming from the Motion Detector, allow the coffee filter to drop straight down.

6. Examine the distance vs. time graph for the falling coffee filter.
- After data collection stops, a graph of distance vs. time will be displayed.
  - To examine the data pairs on the graph, tap  or any data point. As you move the examine line, the distance and time values of each data point are displayed to the right of the graph. Examine the graph and discuss it with your lab partners. If it is satisfactory, sketch the graph in the space provided in the Data section. Label the important features of your graph. If necessary, repeat the drop.



*Coffee Filter Distance vs. Time Graph*

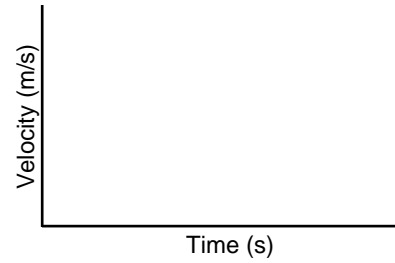
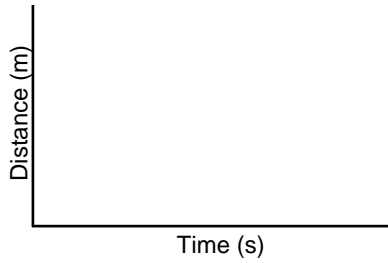
- Position the examine line at the filter's drop point. See the example above. Record the time (in seconds) and distance (in meters) in the data table (round to the nearest 0.01).
  - Position the cursor at the filter's landing point. See the example above for the location of the landing point. Record the time (in seconds) and distance (in meters) when the filter landed in the data table (to the nearest 0.01).
7. Examine the velocity vs. time graph for the falling coffee filter.
- Tap the y-axis label and choose VEL(m/s) to display a velocity vs. time graph.
  - Examine the graph and discuss it with your lab partners. Sketch the graph in the space provided in the Data section. Label the important features of your graph.
  - Position the cursor at the highest point on the velocity vs. time graph. Record this highest velocity (in m/s) in the data table (round to the nearest 0.01 m/s).

### Part B Falling Book

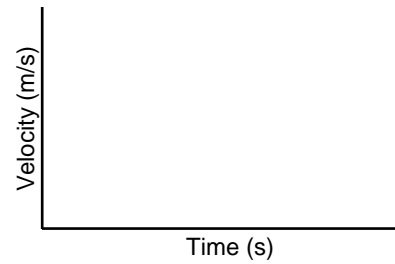
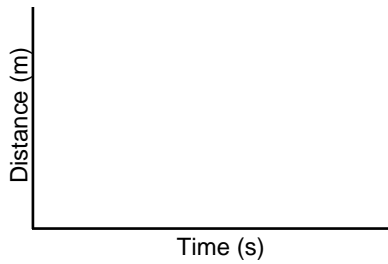
8. Collect data for a falling book.
- Tap on the y-axis label and choose DIG/SON 1: DIST(m).
  - Repeat Steps 5-7 using a book.

# DATA

## Falling Coffee Filter



## Falling Book



### Falling Coffee Filter

	Time (X)	Distance (Y)
Drop Point	_____ s	_____ m
Landing Point	_____ s	_____ m

### Falling Book

	Time (X)	Distance (Y)
	_____ s	_____ m
	_____ s	_____ m

Maximum Velocity \_\_\_\_\_ m/s

\_\_\_\_\_ m/s

## **PROCESSING THE DATA**

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

Falling Coffee Filter

Falling Book

2. How do the falling times compare?

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

Falling Coffee Filter

Falling Book

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

5. Which object fell faster? Why?

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

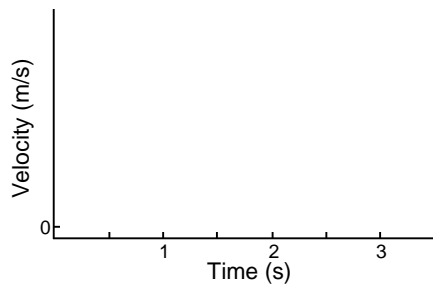
7. How are the two velocity vs. time graphs different? Explain the differences.

## Experiment 40

---

- Compare the maximum velocities of your two objects. Which object was falling faster when it landed? Why was it falling faster?
- For which object is air resistance more important? Why does air resistance affect this object more than the other object?
- 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*.

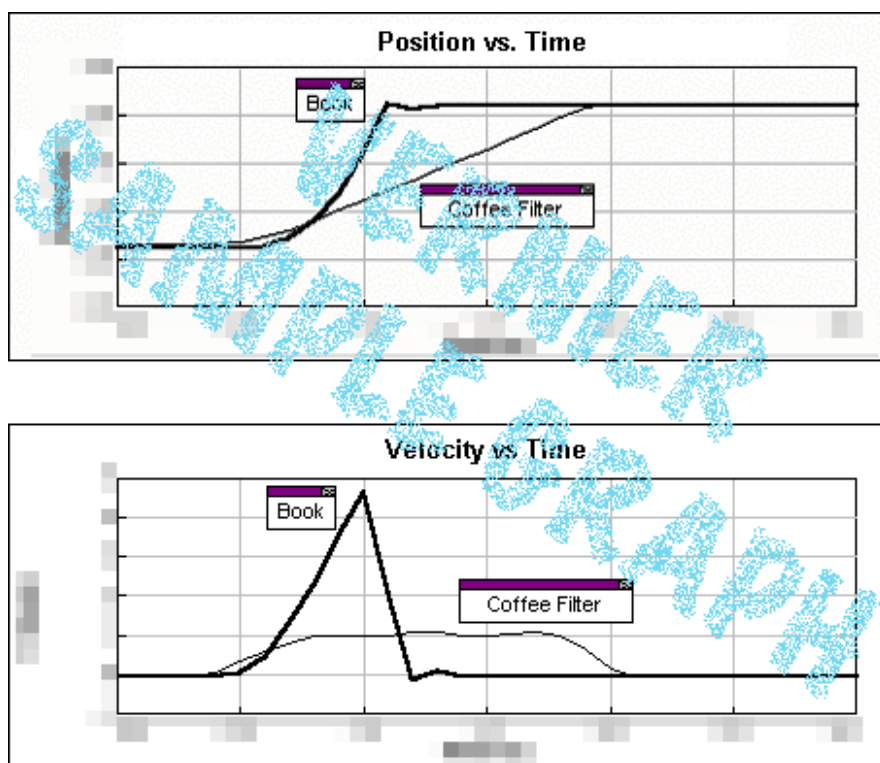
- Did either of your objects reach terminal velocity? If so, which one?

## EXTENSION

- Determine the average terminal velocity of a coffee filter in five falls.

**TEACHER INFORMATION****Falling Objects**

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. Have the experiment area as free of obstacles as possible. Ultrasound reflections from tables, desks, and their edges can give unexpected results.
3. The motion detector must extend 50 cm beyond the table edge. Alternatives to the ring stand, right-angle clamp, and rod for suspending the Motion Detector include taping it to a board or rigid meter stick supported by a book shelf, cabinet, or stack of books on a table.
4. We gratefully acknowledge the contributions to the design of this experiment by Rick Sorensen of Vernier Software & Technology.

**SAMPLE RESULTS**

## ***Experiment 40***

---

	<b>Falling Coffee Filter</b>		<b>Falling Book</b>	
	Position(Y)	Time (X)	Position (Y)	Time (X)
Drop Point	xxxx m	xxxx s	xxxx m	xxxx s
Landing Point	xxxx m	xxxx s	xxxx m	xxxx s
Maximum Velocity	xxxx m/s		xxxx m/s	
Curve shape in maximum region	xxxx		xxxx	

## **ANSWERS TO QUESTIONS**

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.