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. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to DIG 1 of LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

3. On the Meter screen, tap Rate. Change the data-collection rate to 10 samples/second and the data-collection length to 3 seconds. Select OK.

4. 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. Start data collection.
   c. When you hear sound coming from the Motion Detector, allow the coffee filter to drop straight down.

5. Examine the distance *vs.* time graph for the falling coffee filter.
   a. After data collection stops, a graph of position *vs.* time will be displayed. To examine the data pairs on the graph, tap any data point. As you tap each data point, the position and time values 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.
   b. Tap the data point at the filter's drop point. Record the time (in seconds) and distance (in meters) in the data table. Round to the nearest 0.01.
   c. Tap the filter's landing point. Record the time (in seconds) and distance (in meters) when the filter landed in the data table (to the nearest 0.01).

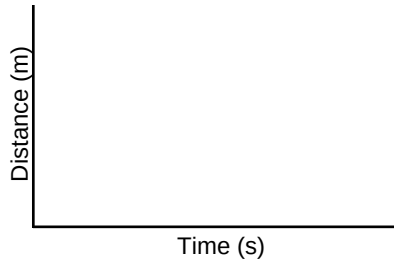
6. Examine the velocity *vs.* time graph for the falling coffee filter.
   a. Examine the velocity *vs.* time graph and discuss it with your lab partners. Sketch the graph in the space provided in the Data section. Label the important features of your graph.
   b. Tap the highest point on the velocity *vs.* time graph. Record this highest velocity (in m/s) in the data table (round to the nearest 0.01 m/s).

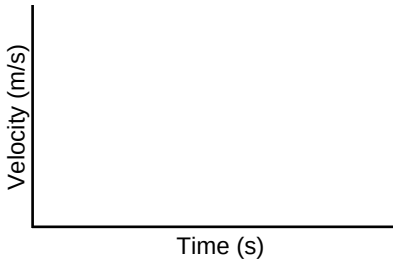
Part B Falling Book

7. Repeat Steps 4–7 using a book.

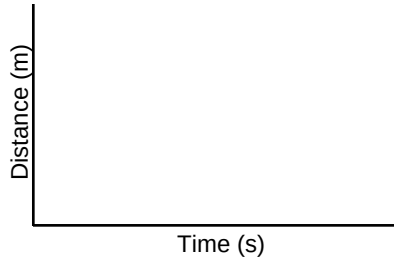
DATA

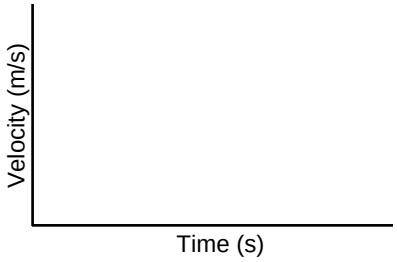
Falling Coffee Filter





Falling Book





	Falling Coffee Filter		**Falling Book**	
	Time (X)	Distance (Y)	Time (X)	Distance (Y)
Drop Point	_____ s	_____ m	_____ s	_____ m
Landing Point	_____ 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?

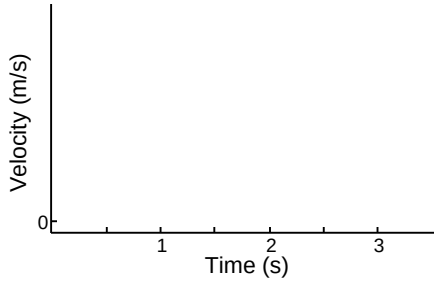
6. How are the two distance *vs*. time graphs different? Explain the differences.

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

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?

EXTENSION

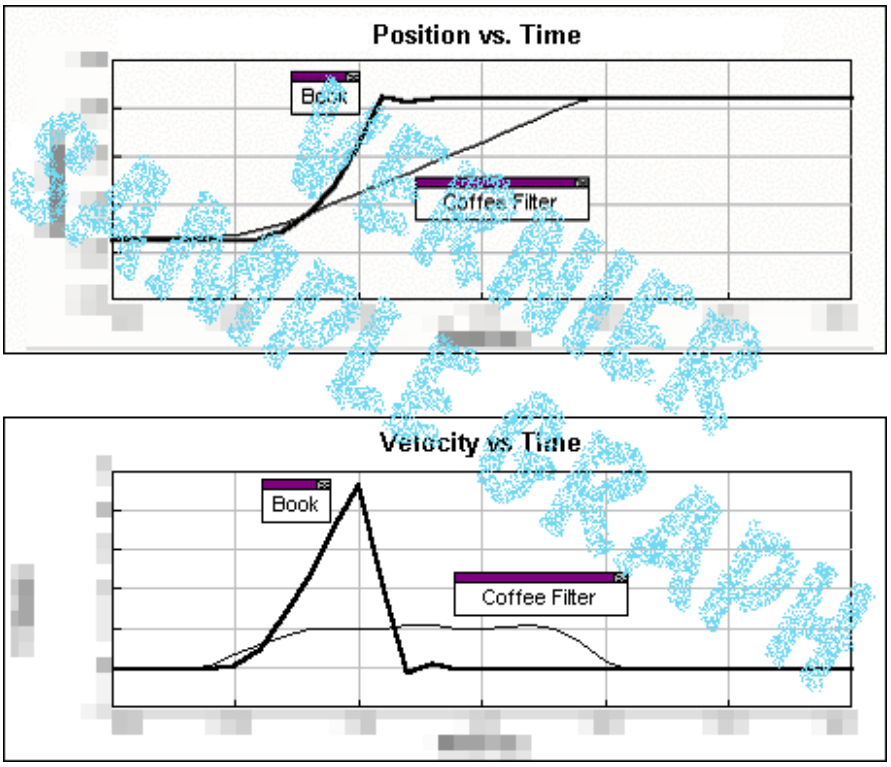
1. Determine the average terminal velocity of a coffee filter in five falls.

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



	Falling Coffee Filter		Falling Book	
	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.