# LAB 3. HOW THINGS MOVE

## Supplies

**Spring Station:** spring, hanging mass, support for hanging, motion sensor setup
**Drop Station:** clamping support, tape timer, ticker tape, hanging weight, pad
**Everyday station:** motion sensor setup, box

## Lab activities

### Activity1. Spring mass

#### *What to do*

1. Hang a mass from the spring.
2. Point the motion sensor under the spring facing upward.
3. Lift the mass and release so that it oscillates up and down.
4. Start the motion sensor. Make graphs of position, velocity and acceleration.
5. Consider the questions below. When you have good answers, call the instructor. Show the instructor your graphs and explain your answers.

#### *Questions to consider*

- What functional form do the graphs take?
- What is the relationship between the position, velocity, and acceleration?

### Activity 2. Drop

#### *What to do*

In this activity, you will drop a weight hanging from a length of paper tape so that it falls freely and draws the tape between a metal plate and a circle of carbon paper on the timer. The Pasco Tape Timer strikes the metal plate at a frequency of 40 hertz, making a mark on the paper at regular intervals of 1/40 sec.

1. Set a book or pad under the tape timer to catch the falling weight.
2. Cut a piece of paper tape long enough to reach from the timer to the floor, with about 50 cm excess.
3. Thread one end of the tape through the slots on the timer, from top to bottom. Make sure that the tape runs between the metal bar and the circle of carbon paper.
4. Fold over the lower end of the paper and hook the weight through both layers. (This keeps the paper from tearing.)
5. Hold the rest of the tape above the timer so that the mass hangs just below the bottom of the timer. Turn on the timer to 40 Hz. Let it run for a few seconds to get up to speed.
6. Drop the tape, allowing the weight to fall freely.
7. Turn off the timer. Remove the tape from the timer and fasten it to the table with masking tape.
8. Repeat this procedure for a second trial.

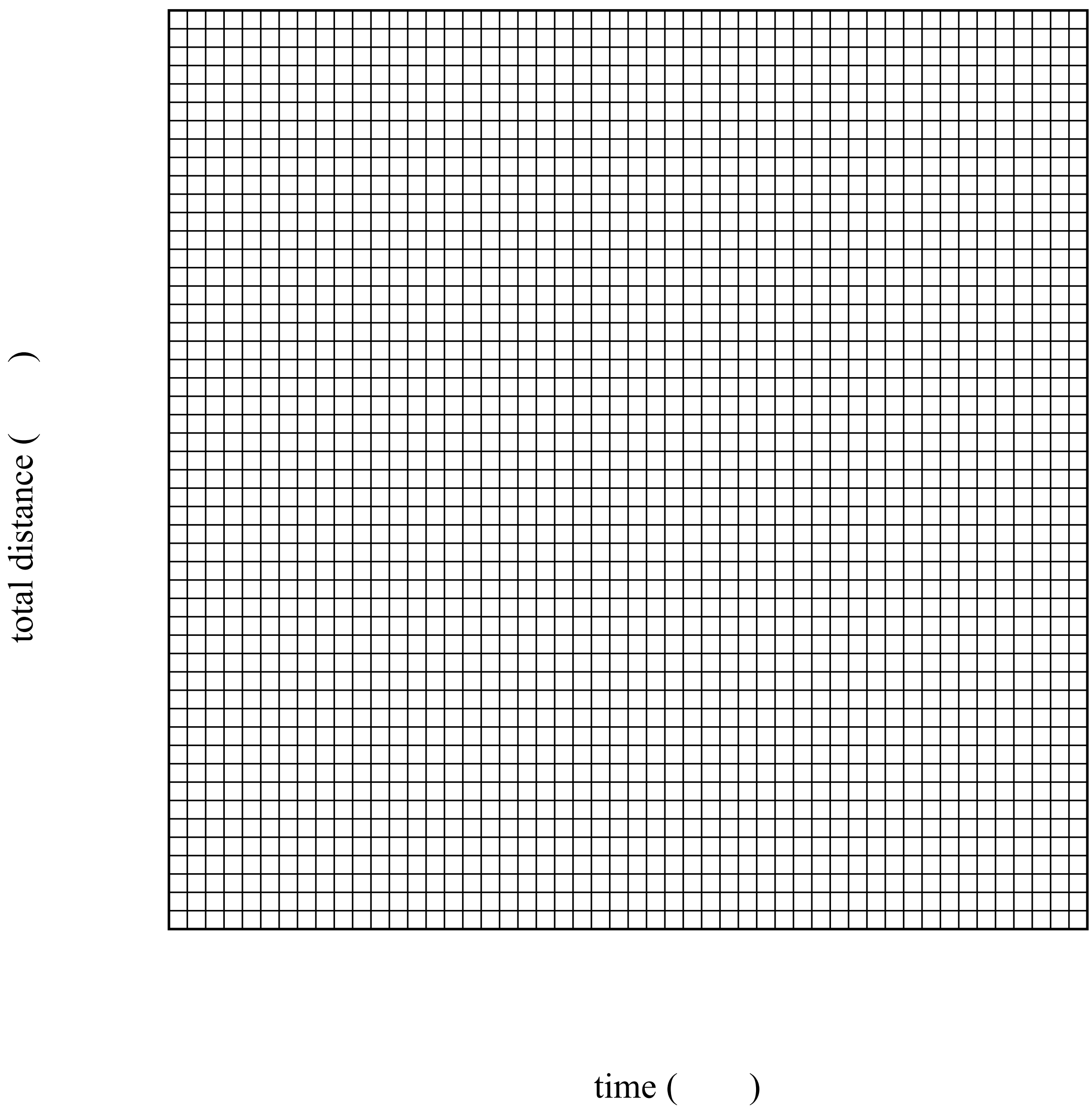
9. Complete the table by following these steps for each trial.
10. Choose a starting point a few centimeters past the first group of dots and mark that dot as Position 0. (The first several dots are unreliable—do you see why?) Measure the *total* distance from Position 0 to each successive dot for up to 15 dots. (The last few dots on the tape are also unreliable—again, do you see why?) Record these values in the Table.
11. In the next column of the table, calculate the distance $\Delta d$ between successive dots by subtracting the position of the previous dot. If you wish, you may use a spreadsheet.
12. In the final column, calculate the average speed of the falling mass in each interval between successive dots using the relation $v = \Delta d/\Delta t$. Since the timer was set on 40 Hz, it was making 40 dots per second, so the time between successive dots is 1/40 s or 0.025 s. Numerically, this means you should multiply the number in the $\Delta d$ column by 40. Do *not* divide $d$ or $\Delta d$ by the number in the "Time" column.

**Table. Falling mass**

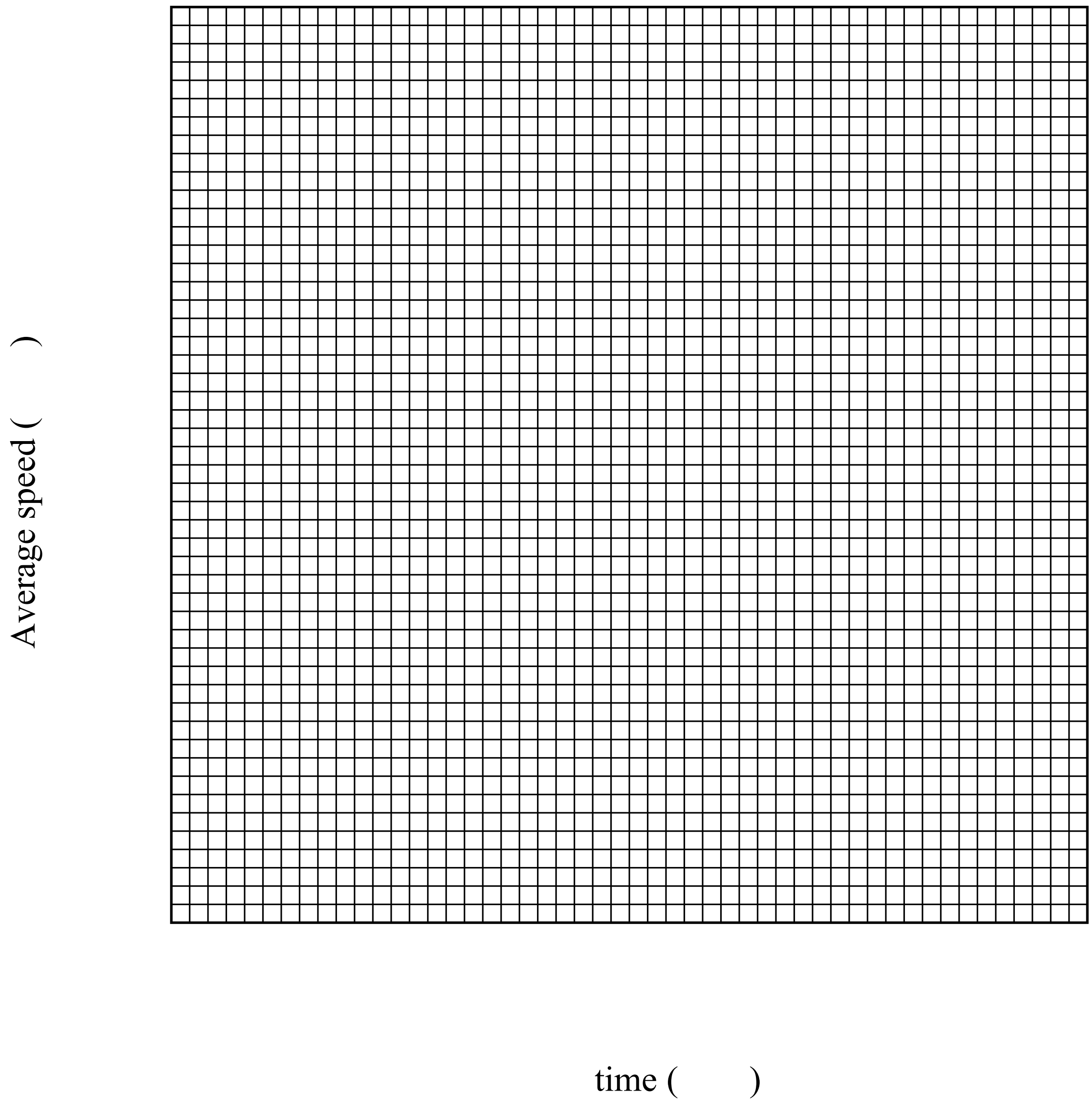
| Dot | Time $t$ (s) | Trial 1 | | | Trial 2 | | |
|---|---|---|---|---|---|---|---|
| | | Total Distance $d$ (cm) | Change in Distance $\Delta d$ (cm) | Average Speed $v$ (cm/s) | Total Distance $d$ (cm) | Change in Distance $\Delta d$ (cm) | Average Speed $v$ (cm/s) |
| 0 | 0 | 0 | — | — | 0 | — | — |
| 1 | 0.025 | | | | | | |
| 2 | 0.050 | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |

***Analysis***

1. Make a plot of total distance vs. time from your measurements in the Table. Plot both sets of data on the same graph, using different plot symbols and colors for them. Scale your graph to use at least half of each axis. Include a legend on your graph to tell which is which. Enter the units in the axis labels. Title your graph.



2. Make a graph of the velocity vs. time from your measurements in the Table. Plot both sets of data on the same graph, using different plot symbols and colors for them. Include a legend with your graph to tell which is which. Enter the units in the axis labels. Scale your graph to use at least half of each axis. Title your graph.




3. Using a ruler, draw a straight line that best approximates the points from Trial 1. Draw another line for the Trial 2 points.
4. Do straight lines closely approximate the data? What does that mean?
5. Determine the slope of each line.
6. What do the slopes represent?

## Activity 3: Everyday stuff

### *Sprinter*

1. Set up the motion detector to follow a person.
2. Take data of a person sprinting from rest, toward or away from the detector.
3. Create the position-time graph.
4. Make velocity-time and acceleration-time graphs if you think they might help you understand the motion.

### *Sliding box*

1. Set up the detector to follow a box.
2. Start data collection.
3. Push the box toward the detector and let it slide to a stop along the floor.
4. Create the position-time graph.
5. Make velocity-time and acceleration-time graphs if you think they might help you understand the motion.
6. Consider the questions below. When you have good answers, call over the instructor. Show the instructor your graphs and explain your answers.

### *Questions to consider*

- How would you describe the motion of the sprinter?
- How would you describe the motion of the sliding box?