

## Physics 100

# Lab 1: Motion

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This lab is not a true experiment. Instead, you will perform a series of activities which will enable you to get a feeling for the concepts of *distance* and *velocity*.

### Theory: The motion detector

The motion detector emits a very high-pitched sound, referred to as the “signal,” and then detects that signal if it happens to bounce off of an object and back to the detector. Information from the detector is fed to a computer. By timing how long it takes from when the signal first leaves the detector to when it returns after bouncing, the computer can calculate the distance between the detector and the object from which the signal bounced. By keeping track of how the distance from the detector changes with time, the computer can also estimate the instantaneous velocity and acceleration at any moment. In this lab and in the next, we will be using the detector and the computer to which it is connected as *a tool for keeping track of the instantaneous distance from the detector, velocity, and acceleration of a moving object*. There are some details about how the detector works that you need to know:

- The detector cannot detect anything closer than 0.5 m to it,
- The signal comes out of the detector in a cone of  $15^\circ$  width,
- Bulky soft clothing (such as thick sweaters) will absorb the signal instead of bouncing it back,

## ACTIVITY 1: LEARNING TO USE THE MOTION DETECTOR AND ITS SOFTWARE

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- Calculations of velocity and acceleration done by the computer are extremely sensitive to small variations in motion, so you should try to move the object as smoothly as possible. Even if you think you are moving it smoothly, and even if the position versus time graph looks smooth, you may find the velocity versus time graphs and the acceleration versus time graphs are extremely choppy.
- The software assumes that the detector is at the position “zero,” and that movement *away from the detector* gives a *positive* velocity.

### Activity 1: Learning to use the motion detector and its software

Connect the motion detector to **PORT2** of the **ULI** (universal lab interface; the **ULI** should already be connected to the computer).

Double-click on the **Logger Pro** application on the Desktop. Once it gets going, go the **File** menu and choose **Open**. Then go to folder **Probes & Sensors** and then the subfolder **Motion Detector**. Within that, select **Motion Detector.MBL**. If it asks you to **Set Up Interface**, set it on **COM1** and click “Scan.”

Play with the various settings. For example, you will notice three panes on your screen to start with. Go to the **View** menu and pick **Graph Layout**; select “1 Pane.” Then go back into the **View** menu and pick **Graph Options**. In **Axis Options**, for the Y axis, unclick “velocity” and click “distance.” And then, click on the graph title (“Velocity vs. Time”) and enter a more appropriate graph title.

Check what happens when you click on arrows and numbers on graph axes etc.

Each person in your group should try being the “moving object” and make a distance versus time graph, while looking at the distance graph on the screen. Adjust the computer screen so that you can watch it while you are moving. Try constant distance (standing still), constant velocity (moving forward or backward with constant speed), and constant acceleration (moving forward or backward with uniformly increasing (or decreasing) speed).

### To hand in for activity 1

*Nothing.*

## Activity 2: Matching a position versus time graph

Open [Distance Match.MBL](#), where you are to match a distance versus time graph. First, look at the graph you will be trying to match. Discuss with your lab partners when you will be walking toward the detector and when you will be walking away from the detector. In addition, figure out when your speed will be increasing, when it will be decreasing, and when it will be constant. Now click “Collect” and try walking in such a way that the distance versus time graph of your motion matches the distance versus time graph which is already there. Each person should repeat this step until a qualitatively good match is obtained. Make a printout of each person’s best run, and write that person’s name on the printout.

### To hand in for activity 2

On *one* graph for each person: Computer generated graph and graph of attempted match for each member of the group.

## Activity 3: Matching a velocity versus time graph

Open [Velocity Match.MBL](#), where you try to match a *velocity* versus time graph. Follow the same general procedure as in activity 2 above. Don’t forget that you are now looking at a velocity versus time graph, not a distance versus time graph. Again, decide beforehand when you should be moving toward the detector and when you should be moving away from the detector, and when your speed should be increasing, decreasing, or constant. Each person should repeat this step until a qualitatively good match is obtained. Make

## ACTIVITY 4: ESTIMATING AVERAGE VELOCITY FROM A DISTANCE VERSUS TIME GRAPH

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a printout of each person's best run, and write that person's name on the printout.

### To hand in for activity 3

On *one* graph for each person: Computer generated graph and graph of attempted match for each member of the group.

## Activity 4: Estimating average velocity from a distance versus time graph

Revisit [Motion Detector.MBL](#).

Have one person in your group make a distance versus time graph while moving at constant velocity, and while watching the distance versus time graph *only*. The distance versus time graph should be a straight line sloping up or down; it may take a few tries to get a nice graph.

Make a printout of the graph, and estimate your velocity by finding the slope of the distance versus time graph. In other words, find how much distance you covered and divide it by how much time you took to cover it. Show your calculation on the graph, and write your estimated average velocity on the graph. Was your average velocity positive (away from the detector) or negative (toward the detector)?

Now look at the velocity versus time graph for that same motion (going into the [View](#) menu as described in Activity 1), and estimate the average velocity from *that* graph. Write that result on your graph, and note to what degree it agrees (or disagrees) with your estimate from the position versus time graph.

### To hand in for activity 4

One distance versus time graph with:

- Calculation of estimated average velocity,
- Estimated result from computer-generated velocity versus time graph.

## Activity 5: Drawing a graph from a description of the motion

Draw a distance versus time graph and a velocity versus time graph for an object which:

- First moves with a constant slow speed away from the origin for 5 s,
- Then moves with a constant faster speed away from the origin for the next 5 s,
- Then stands still for the next 5 seconds,
- Finally, moves with a constant slow speed toward the origin for the last 5 s.

*Note:* Both graphs should refer to the same motion.

### To hand in for activity 5

- Hand drawn position versus time graph (only one per group),
- Hand drawn velocity versus time graph (only one per group).