College Physics I

# Lab 1: Motion

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This lab is not a true experiment; it will just introduce you to how labs go. You will perform a series of activities which will enable you to get a feeling for the concepts of *distance* and *velocity.*

## The motion detector

The motion detector emits a high-pitched sound and then detects that signal if it happens to bounce off of an object and back to the detector. 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 about 0.5 m to it,
- The signal comes out of the detector in a cone of about 15° width,
- Bulky soft clothing (such as thick sweaters) can absorb the signal instead of bouncing it back,

- 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.

## Using the motion detector and its software

Connect the motion detector to DIG/SONIC 1 of the green Vernier LabPro interface device. Make sure the device has power—you will see a green LED light.

Double-click on the Logger Pro application on the Desktop. Once it gets going, go the File menu and choose Open. The go to folder Physics with Vernier. Select 01a Graph Matching.cmbl.

To collect data, click on the "Collect" button. If you do this you will notice that the motion detector emits a clicking sound. Move yourself or some object toward or away from the motion detector while it is clicking and watch what happens.

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) velocity).

## Part 1: Matching a position vs time graph

Open 01b Graph Matching.cmbl, 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 velocity 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 you get a qualitatively good match.

Make a printout of each person's best run, using the "Print Graph" menu item. Write that person's name on the printout. Make sure that your computer is set up to print from the printer in MG 1004—it's the default, but things occasionally get messed up.

### To hand in for part 1

On *one graph for each person*: Computer generated graph and graph of attempted match for each member of the group. (You still will put everything together and turn in a single lab report as a group.)

## Part 2: Matching a velocity vs time graph

Open 01d Graph Matching.cmbl, where you try to match a *velocity* versus time graph. Follow the same general procedure as in part 1. 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 you get a qualitatively good match. Make a printout of each person's best run, and write that person's name on the printout.

### To hand in for part 2

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

## Part 3: Estimating average velocity from a distance versus time graph

Open 01a Graph Matching.cmbl again.

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)?

After completing this estimation, look at the velocity versus time graph for that same motion. Click on the red "Position (m)" label on the vertical axis and select "Velocity" instead. Click and drag on the vertical axis to adjust its position. Also double click on a number on the axis, then go to the "Axes Options" to change the axis scale. Play with these until you get the velocity graph to fit the screen fully, with not too much white space on the graph.

Now print out that graph, 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. Should they agree?

### To hand in for part 3

- One distance versus time graph with calculation of estimated average velocity,
- Estimated result from the corresponding computer-generated velocity versus time graph.

## Part 4: Drawing a graph from a description of the motion

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

- 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 part 4

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