Physics 131 Lab 1: 
ONE-DIMENSIONAL MOTION

OBJECTIVES

☐ To familiarize yourself with motion detector hardware.
☐ To explore how simple motions are represented on a displacement-time graph.
☐ To measure the motions of your own body in one dimension.
☐ To understand the relation between displacement-time and velocity-time graphs in one dimension.

INVESTIGATION 1: DISPLACEMENT-TIME GRAPHS OF YOUR MOTION

When we want to give a physical description of an object, we will usually want to know where it is. Making a continuous graph of its position over time allows us to track its motion.

We will be making a displacement-time graph using our data. This means that what we are measuring is actually the physical separation between our detector, which we define as the origin for measurement purposes, and the object, in this case your body. We could also call our graphs “position-time” or “distance-time” graphs.

You will need the following materials:

☐ motion detector hooked up to your lab workstation
☐ two-meter ruler or number line on floor

Activity 1-1: Making and Interpreting Displacement-time Graphs

1. Open Data Studio and make sure that your motion detector is connected and that the computer recognizes it. If there is any data that was not cleared from the previous user, select File > New Activity.

2. If a graph labeled “Position” is not already displayed, find “Position (m)” under Data on the left side of the screen and click and drag it to “Graph”.

3. To make sure that your ruler or number line markings agree with the motion detector, have one partner stand at the 2-m mark while another takes data at the computer. Have the partner being measured move back and forth until the sensor reads 2 m. Then place the 2-m mark of the ruler accordingly.

4. Move steadily until you are about 3 meters from the sensor. If at any time the sensor stops recording your proper position, you may want to try tipping the sensor “up” a little so that it points more toward the ceiling. If you have spurious spiking, or the sensor is already “up” and you still don’t get far readings, the sensor may be looking at other objects (computer monitor, etc.) and you may want to pick another pathway for your motion.
You are now ready to take your first experimental data.

5. Graph each of the following experiments. Each member of the group should walk at least one and take data for at least one experiment.

(a) Start at .5 m and walk away from the detector slowly and steadily (at constant speed).

(b) Start at .5 m and walk away from the detector medium fast and steadily.

(c) Start at 2 m and walk toward the detector slowly and steadily.

(d) Start at 2 m and walk toward the detector medium fast and steadily.

When you have a good graph for each of these, print out one graph with all four on it, clearly labeled, to turn in at the end of lab.

**Question 1.1:** Compare graph (a) with graph (b) and (c) with (d). What does the difference between the slopes tell you about your speed in each experiment?

**Question 1.2:** Compare your graphs for (b) and (d). Which one has a positive slope and which one a negative? What does this say about the direction you are moving?

We can now examine the data a little more quantitatively.

6. Select one of your graphs which has a fairly straight line and drag a box around those data points with your mouse.

7. Select “Fit” > “Linear”, and a line will appear which best approximates the data points. You will also see a box with this line’s statistics, including its slope (abbreviated m), which is what we are interested in right now.

**Question 1.3:** The formula for slope is \( m = \frac{x_2 - x_1}{t_2 - t_1} \), or distance traveled (or, more precisely, change in position) divided by elapsed time. How is this usually referred to?
Prediction 1-1: Predict the position-time graph produced when a person starts at the 1-m mark, walks away from the detector slowly and steadily for 5 seconds, stops for 5 seconds, and then walks toward the detector twice as fast as he or she walked away from it. Draw your prediction on the axes below using a dashed line. Compare your predictions with those made by others in your group. Draw your group’s prediction on the axes below using a solid line. (Do not erase your original prediction.)

8. Test your prediction. Graph one of your group members moving in the way indicated. When you are satisfied with your graph, print out a copy to turn in at the end of lab.
INVESTIGATION 2: MATCHING DISPLACEMENT-TIME GRAPHS

In the last investigation, we described motions to you in words, which you then used to produce graphs. In this investigation, you will take graphs like the ones you made in the previous investigation and turn them into motion.

Activity 2-1: Matching a Given Graph

1. Open the experiment file on the desktop called Position Match 1. A graph like that shown below will appear:

   ![Graph Image]

2. Try to move so as to duplicate the given graph on the computer screen. Each group member should try at least once.
3. Print out your best graph to turn in at the end of lab. Don’t be too perfectionist here – there is a lot more lab to do.

Activity 2-2: Matching Graphs from your Group

1. Switch papers among your group so that no one has their own lab manual. Sketch a displacement-time graph on the axes that follow. Use straight lines only. Be creative!

   ![Graph Image]

2. Return the lab manuals to their owners. Each person should try to duplicate the graph they were given.
3. Once a group member has successfully duplicated his or her graph, he or she should print out a copy to turn in at the end of lab.
Activity 2-3: Curved Graphs

Walking a curving graph is a good deal harder than walking one composed of straight lines.

1. Try to duplicate the shape of the following three graphs on your computer screen. Each group member should try at least one of these.

   ![Graph A](image1)  ![Graph B](image2)  ![Graph C](image3)

2. Describe in words how one needs to move to get a displacement-time graph with the shapes shown. You don’t need to print the graphs out.

   Graph A answer:

   Graph B answer:

   Graph C answer:

INVESTIGATION 3: VELOCITY-TIME GRAPHS OF MOTION

You have already plotted your position along a line as a function of time. Another way to represent your motion during an interval of time is with a graph that describes how fast and in what direction you are moving. This is a velocity-time graph.

Velocity is the rate of change of position with respect to time. It is a “vector quantity”: that is, it is a measure of both an object’s speed (how fast it is moving) and also the direction it is moving in. Motion away from the origin is indicated by a positive velocity, motion toward by negative velocity.

Graphs of velocity vs. time are more challenging to create and interpret than those of position. A good way to learn to interpret them is to create and examine velocity-time graphs of your own body motions, as you will do in this investigation.

You will need the following materials:
- motion detector
- number line on floor in meters or measuring tape
Activity 3-1: Making Velocity Graphs

1. Click “Setup” at the top of the Data Studio screen. Check the box next to “Velocity” under the motion sensor. This will allow you to graph both your measured position and your velocity.

2. Make a graph of each of the following four experiments. Each group member should walk at least one and record data for at least one. You may redo each experiment until you get a graph that you are satisfied with. When you have a satisfactory result for each experiment, print out one graph with all four sets of data on it to turn in at the end of lab. Be sure to notate clearly which set of data corresponds to each experiment.

   a. Make a velocity graph, walking away from the detector slowly and steadily.
   b. Make a velocity graph, walking away from the detector medium fast and steadily.
   c. Make a velocity graph, walking toward the detector slowly and steadily.
   d. Make a velocity graph, walking toward the detector medium fast and steadily.

Question 3-1: How do the graphs made by walking slowly differ from those made by walking more quickly?

Question 3-2: How do the graphs of motion away from the detector differ from motion toward the detector?

Prediction 3-1: Imagine the following motion:

• Walk away from the detector slowly and steadily for about 5 seconds;
• stand still for about 5 seconds;
• walk toward the detector steadily about twice as fast as you walked away from it.

Predict the velocity-time graph which would result. Each member should sketch his or her prediction on the following axes with a dotted line, then the whole group should agree on a prediction and draw it in with a solid line.
3. Test your prediction. Begin graphing and repeat your motion until you think it matches the description given. Print out a copy of the best graph to turn in at the end of lab.

Activity 3-2: Matching a Velocity Graph

In this activity, you will try to move to match a given velocity-time graph. This is much harder than matching a position graph as you did in the previous investigation. Most people find it quite a challenge at first to move so as to match a velocity graph.

1. Open the experiment file Velocity Match 1 from the desktop to display the velocity-time graph shown below on the screen.

![Velocity-Time Graph](image)

Prediction 3-2: Describe in words how you would move so that your velocity matched each part of this velocity-time graph.

0 to 4 s:

4 to 8 s:

8 to 12 s:

12 to 18 s:

18 to 20 s:

2. Begin graphing, and move so as to imitate this graph. Try to do this without looking at the computer screen. As always, you may try as many times as you need. Work as a team and plan your movements. Get the times right. Get the velocities right. Each person should take a turn. It is quite difficult to obtain smooth velocities. Do not expect the lines on your graph to be perfectly straight, but try to minimize variability as much as possible. Print out your group’s best match to
Question 3-3: Is it possible for an object to move so that it produces an absolutely vertical line on a velocity-time graph? Explain. (Hint: is velocity a function?)

Question 3-4: Did you have to slow down to avoid hitting the motion detector on your return trip? If so, why did this happen? How would you solve the problem? If you didn’t have to stop, why not? Does a velocity graph tell you where to start? Explain.

End-of-lab Checklist:

Make sure you turn in:
- Your lab manual sheets
- Graphs from Activities 1.1, 2.1, and 2.2.
- Answers for all questions and predictions