LAB 2 INTRODUCTION TO MOTION (TPL1)

Goals:

- Measure your motion with the motion detector
- Observe the motion on the graphical screens
- Investigate the “limits” of the motion detector
- Save the motion in a data file
- Understand the relationship between distance-time and velocity-time graphs
- Predict velocity graphs from distance graphs

Introduction:

We will use computerized sensors to collect live data in physics labs. There is also a conceptual change from the way traditional physics labs are performed. Because of the instantaneous data collection, there is the opportunity to make several data runs, until the session is acceptable. There is also an opportunity to ***make a prediction*** and then ***test the prediction with an observation***. This will be an integral part of the laboratory experience during this course.

One key to understanding a particular concept is to have the observations compared with predictions. If the predictions are correct (as seen by the observations), the observations will strengthen that concept. If the predictions do not match the observation, there is a chance for re-measurement (or for a challenging of the prediction). Through this procedure, the correct concepts can be strengthened, and the incorrect concepts can be eliminated.

The individual lab write-ups in the Lab Manual will contain prediction sections and observation sections. It is very important to write down the predictions as completely as possible before performing that part of the experiment.

Part A - Supplement – Using DataStudio

1. Load Supplement file. If you have never used DataStudio, or need a “refresher”, then take a look at this help document: Using DataStudio.

Part 1 - Measuring distance with the sensor

The DataStudio program reads an ultra-sonic detector to measure position, velocity and acceleration. The sensor sends out a signal that reflects from a target and comes back to the sensor. The computer graphs the distance, velocity and acceleration as a function of time.

As you walk (or jump, or run), the graph on the computer screen displays how far away from the detector you are. The detector will pick up anything in its path (a cone shape spreading out from the detector). There is a switch on the sensor for the “people walking” mode and the “cart” mode – we’ll use the “people walking” mode for this lab (you’ll see it on the help page).

Preliminary activities

1. Prepare equipment. Connect the motion sensor through USBLink to your laptop. It would be very helpful to look at the online help page for this lab. Start the DataStudio software.

2. Load the experiment file. Download the DataStudio file **`Lab02_SimpleMotion.ds`** from the lab schedule webpage, and open it in DataStudio.

3. Prepare program for graphing. Make sure the graph layout is set to display one graph - Distance vs. Time (with the Time axis set for 60 seconds, and the Distance axis to measure from 0 to 2 meters). [See the graph layout help page for information on how to make these changes in DataStudio.]

4. Starting the graphing process. When you are ready to start graphing, click the START button in the middle of the toolbar.

5. Move toward/away from the detector. Try moving toward or away from the detector and observe how the graph changes:
How close to the detector can you move and still be "seen"?
How far from the detector can you still be "seen"?
If you swing your arms when you walk, does that affect the graph?
Can you move very far sideways to the direction of the detector?

6. Record observations. Write down your observations about the minimum distance, the maximum distance (and what affects it), how does your specific motion (arms waving?) affect the graph, how does the direction of your motion reflect in the graph?

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Part 2 - Making Distance-Time Graphs

We will now make specific distance-time graphs to look at changes in walking speed and direction of motion. This is an important section, because it connects *your motion* with *how it is displayed*.

1. Prepare program for graphing. Set the time scale from 0 to 20 seconds. Record distance-time graphs (and sketch them on the Data/Question sheets) for the following motions:

A) Walking away. Start at 50 cm from the detector, and walk away from the detector slowly and steadily.

Draw the graph on the Data/Question sheets.

B) Walking away faster. Start at 50 cm from the detector, and walk ***away*** from the detector ***medium-fast and steadily.***

Draw the graph on the Data/Question sheets.

C) Walking toward. Start at 1-2 m from the detector, and walk ***toward*** the detector ***slowly and steadily.***

Draw the graph on the Data/Question sheets.

D) Walking toward, faster. Start at 1-2 m from the detector, and walk ***toward*** the detector ***medium-fast and steadily.***

Draw the graph on the Data/Question sheets.

When finished with these, stay with the Data/Question Sheets for the following section.

Part 3 - Predicting Distance-Time Graphs

Refer to the Data/Question Sheet for this section.

Part 4 Predicting Velocity Graphs from Distance Graphs

1. Predict a velocity graph from a distance graph. Carefully study the distance graph shown below and predict the velocity-time graph that would result from the motion. Using a dotted line, sketch your prediction of the corresponding velocity-time graph on the velocity axes.

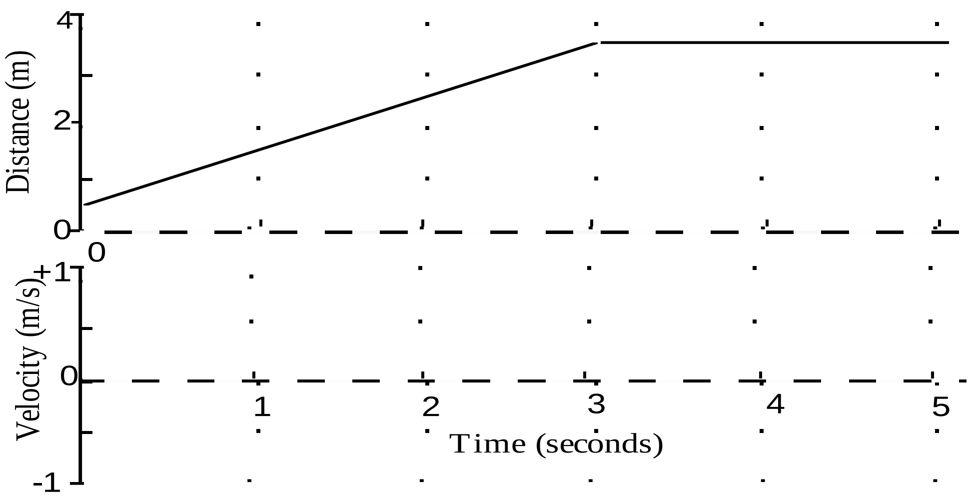


Figure 1 – Predicting Velocity graphs from a given Distance graph

2. Select other graph. In the DISPLAYS list, double-click on the "Vel/Pos v time" graph.

3. Make the graphs. After each person has sketched a prediction for the velocity, press START, and do your group's best to make a distance graph like the one shown above. Walk as smoothly as possible.

4. Sketching the graph. When you have made a good duplicate of the distance graph, sketch your actual graph over the existing distance-time graph. Use a solid line to draw the actual velocity graph on the same graph with your prediction. (Do not erase your prediction).

Questions Answer the following questions on the Data/Question Sheets:
A) How would the distance graph be different if you moved faster? Slower?
B) How would the velocity graph be different if you moved faster? Slower?

C) How did your prediction compare to the actual graph? What were some of the major differences? Was your true graph as smooth as the prediction? If not, what do you think is responsible for the bumpiness? (Explain.)

Part 5 Estimating and Calculating Velocity

1. Estimating the average velocity. You are to estimate an average value for the velocity while you were walking steadily in Part 6. Click on the SMART TOOL icon (it will place a square cross-hairs into the graph which you can move around to identify data points). Read a number of values (say ten) from the velocity graph, and use them to calculate the average (mean) velocity. **Make sure you pick points that are in the "constant velocity" region (the time when the distance was making a positive steady slope)** and record them on the Data Sheets.

Comment Average velocity during a particular time interval is the change of distance divided by the change in time. By definition, this is also the (average) slope of the distance-time graph for that time period. As you have observed, the faster you move, the more inclined is your distance-time graph. The slope of a distance-time graph is a quantitative measure of this incline, and therefore it tells you the velocity of the object.

2. Calculating the average velocity from the distance graph in Part 4. Calculate the slope of the distance vs. time graph. Use the SMART TOOL and read the distance and time coordinates for two typical points while you were moving (again, these have to be in the "constant velocity" region … along that slope). For a more accurate answer, use two points as far apart as possible but still typical of the motion, and within the time interval over which you took velocity readings in Part 5.1. Calculate on the Data/Question sheets. Calculate the change in distance between points 1 and 2. Also calculate the corresponding change in time (time interval). Divide the change in distance by the change in time to calculate the average velocity. Show your calculations on the Data/Question sheets.

3. Calculating the "mean" velocity. Using the SMART TOOL, click in the Velocity graph, and then select a region of the velocity graph where the velocity is reasonably constant (the same area from which you took the 10 points in part 7.1). Then use the "summation" tool to display the MEAN value (basically averaging ALL the points in your selection), the information will show up in the legend. Record the mean velocity on the Data/Question sheets. [There is information about how to use the "summation" tool in the "store and examine" help page.]

4. Drawing the average velocity. On Page 3 (Figure 1), draw a line representing the average velocity on the graph shown in Part 4. (This should be a horizontal line on the velocity graph -- use a dashed line on the graph.)

Questions Answer these on the Data/Question Sheets.

A) Is the average velocity positive or negative? Is this what you expected? (Explain your answer with complete sentences.)

B) Does the average velocity you calculated from the distance graph agree with the average velocity you estimated from the velocity graph and with the mean velocity calculated by the program itself? Do you expect them to agree? How would you account for any differences? (Explain.)

Part 6 Predicting Distance Graphs from Velocity Graphs

1. Predict a distance (position) vs. time graph from a velocity-time graph. Carefully study the velocity graph shown below. Using a dotted line, sketch your prediction of the corresponding distance graph. (Assume that you started at the 1-meter mark.)

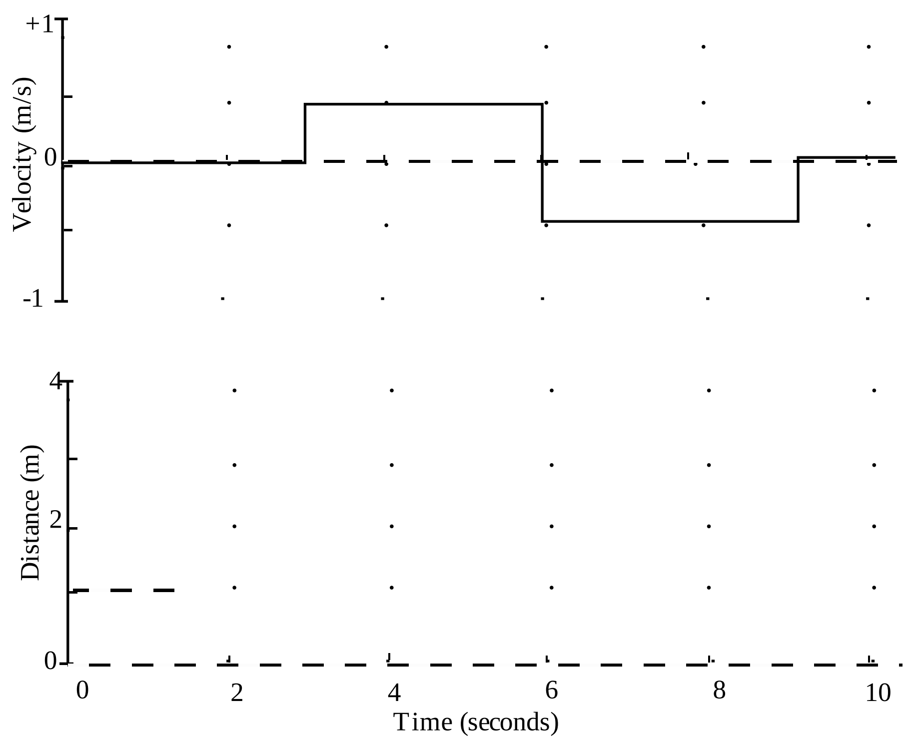


Figure 2 – Predicting a Distance graph from a known Velocity graph

2. Make the graphs. After each person has sketched a prediction, do your group's best to duplicate the top (velocity-time) graph by walking relative to the detector. (Hint: Do you expect to be able to match it exactly?) (Reset the Time axis to 0-10 sec before you start.) When you have made a good duplicate of the velocity-time graph, draw your actual result over the existing velocity-time graph. Use a solid line to draw the actual distance-time graph on the same axes with your prediction.

SAVE YOUR DATA FROM THIS SECTION
(Again, for practice.)

Questions (If necessary, run the program to test the hypothesis as you answer these questions on the Data/Question Sheets.)

A) What information can you find on a velocity-time graph to indicate that the moving object has changed direction?

B) What is the velocity at the moment the direction changes?

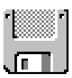
C) Is it possible to actually move your body (or an object) to make completely vertical lines on the velocity graph you were trying to match? [What acceleration would that be?] Why or why not?

D) Is it possible to actually move your body (or an object) to make completely vertical lines on a distance-time graph? Why or why not? [What would the velocity be for a vertical section of the graph?]

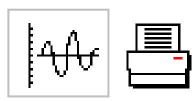
E) What information can you find on a distance-time graph that tells you that your motion is steady (motion at a constant velocity)?

F) How can you tell from a velocity-time graph that your motion is steady?

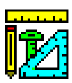
These ICONS may be used in future labs :



Save Data (for future reference or calculation)



This section's graph should be printed for the final report.



This section involves measurement.

The current configuration needs to be checked for a particular feature.

DATA/QUESTION SHEET FOR LAB 2
INTRODUCTION TO USING THE ULI (UNIVERSAL LAB INTERFACE)

Part 2 - Making Distance-Time Graphs

We will now make specific distance-time graphs to look at changes in walking speed and direction of motion. This is an important section, because it connects the motion with how it is displayed.

1. Prepare program for graphing. Set the time scale from 0 to 20 seconds. Make distance-time graphs for the following motions, and sketch the graphs:

2. Walking away. Start at 50 cm from the detector, and walk away from the detector slowly and steadily.

3. Walking away faster. Start at 50 cm from the detector, and walk away from the detector medium-fast and steadily.

4. Walking toward. Start at 1-2 m from the detector, and walk toward the detector slowly and steadily.

5. Walking toward, faster. Start at 1-2 m from the detector, and walk toward the detector medium-fast and steadily.

Questions A) Describe the difference between the graph you made by walking away slowly and the one made by walking away more quickly.

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B) Describe the difference between the graph made by walking toward and the one made walking away from the motion detector.

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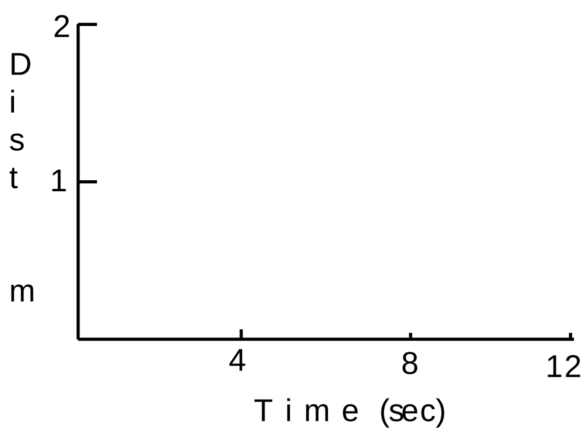
Part 3 - Predicting Distance-Time Graphs

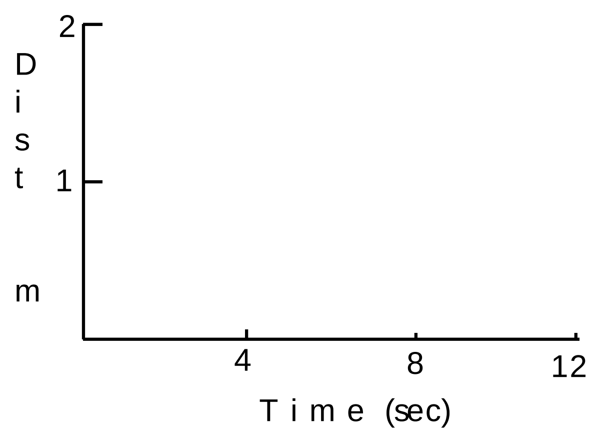
Prediction Predict the graph produced when a person starts at the 1-meter mark, walks away from the detector slowly and steadily for 4 seconds, stops for 4 seconds, and then walks toward the detector quickly. Draw your prediction on the left axes below using a dotted line.

Compare predictions with the rest of your group. See if you all agree. Draw your group's prediction on the left hand axes using a solid line. (Do not erase your original prediction.) *Write the prediction **before** performing the experiment!*

PREDICTION



FINAL RESULT



1. Do the experiment. Move in the way described and graph your motion. When you are satisfied with your graph, draw your group's final result on the right axes.

Question If the final results differed from the prediction, explain why. If the final result is the same, explain the characteristics of the graph and why you chose them.

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Part 4 Predicting Velocity Graphs from Distance Graphs

Questions A) How would the distance graph be different if you moved faster? Slower?

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B) How would the velocity graph be different if you moved faster? Slower?

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C) How did your prediction compare to the actual graph? What were some of the major differences? Was your true graph as smooth as the prediction? If not, what do you think is responsible for the bumpiness? (Explain.)

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Part 5 Estimating and Calculating Velocity

1. Estimating the average velocity.

Velocity values read from graph (m/sec): ____ ____ ____ ____ ____ (They should be
____ ____ ____ ____ ____ very similar!)

Average value of the velocity: _______m/sec

2. Calculating the average velocity from the distance graph in Part 4.

Point 1	Distance _______ m	Time ________ sec
Point 2	Distance _______ m	Time ________ sec

Change in distance: _______ m Change in time: _______ sec

Average velocity = _______m/sec

3. Statistics generated "mean" velocity.

Mean velocity = __________ m/sec

Questions A) Is the average velocity positive or negative? Is this what you expected? (Explain your answer with complete sentences.)

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B) Does the average velocity just calculated from the distance graph agree with the average velocity you estimated from the velocity graph and with the mean velocity calculated by the program itself? Do you expect them to agree? How would you account for any differences? (Explain.)

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Part 6 Predicting Distance Graphs from Velocity Graphs

Questions If necessary, run the program to test the hypothesis as you answer these questions:

A) What information can you find on a velocity-time graph to indicate that the moving object has changed direction?

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B) What is the velocity at the moment the direction changes?

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C) Is it possible to actually move your body (or an object) to make the completely vertical lines on the velocity graph you were trying to match? [What acceleration would that be?] Why or why not?

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D) Is it possible to actually move your body (or an object) to make completely vertical lines on a distance-time graph? Why or why not? [What would the velocity be for a vertical section of the graph?]

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E) How can you tell from a distance-time graph that your motion is steady (motion at a constant velocity)?

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F) How can you tell from a velocity-time graph that your motion is steady?

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Questions/Suggestions → Dr. Changgong Zhou, czhou@ltu.edu