LAB 3: VELOCITY AND ACCELERATION GRAPHS

Goals:

- **Investigate acceleration vs. time graphs**
- **Predict acceleration graphs from velocity graphs**
- **Investigate acceleration as slope of velocity vs. time graph**

Part 1 - Making Velocity-Time Graphs

Preliminary activities

1. Prepare equipment. Connect the motion sensor to the GLX Xplorer, and then to your laptop. It is very helpful to look at the online help page for this lab. Start the DataStudio software in your Windows XP virtual machine.

2. Load the experiment file. Load the DataStudio file `Lab03_VelocityGraphs.ds` from the **Physics1** folder.

3. Prepare program for graphing. Make sure the graph layout is set to display one graph - Velocity vs. Time. [See the graph layout help page for graphing information in DataStudio.]

4. Starting the graphing process. When you are ready, click the ▶ Start button to start data recording.

We will now make specific velocity-time graphs to look at changes in walking speed and direction of motion. This is an important activity, because it connects the motion with the graphical display.

A) Accelerating away. Start at 50 cm from the detector, and walk away from the detector with your speed increasing steadily. Draw the graph on the Data/Question sheets.

B) Decelerating away. Start at 50 cm from the detector, and begin to walk away quickly and then slow down and stop (speed decreasing steadily). Draw the graph on the Data/Question sheets.

C) Accelerating toward. Start at 2 m from the detector, and walk toward the detector with a speed that increases steadily. Draw the graph on the Data/Question sheets.

D) Decelerating toward. Start at 2 m from the detector, and walk toward the detector quickly at first and then slow down steadily and stop (velocity decreasing steadily). Draw the graph on the Data/Question sheets.

When finished with the above activities, follow the instructions on Data/Question Sheets for Part 2.

Part 2 - Predicting Velocity -Time Graphs

Refer to the Data/Question Sheet for this section.

Part 3 - Matching an Existing Velocity-Time Graphs

In this activity you will match a velocity graph shown on the computer screen.

1. Open sample file. Open the **Lab03_VelocityMatch.ds** file. The velocity graph to the right will appear on the screen.

2. Clear any old data. Use Delete All Data Runs from the Experiment menu if necessary.

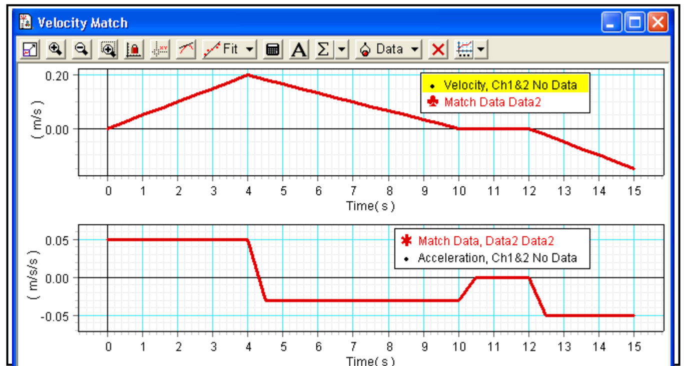
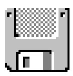


Figure 1 – Velocity matching curve

3. Prepare to match that curve. Click ▶ Start button and move to match the velocity graph shown on the computer screen. You should try to duplicate the features of the Velocity Match graph. You might have to try a number of times. Work as a team. Try to match the times and speeds -- it helps to look at the computer screen as you undergo the motion. Each person should take a turn.

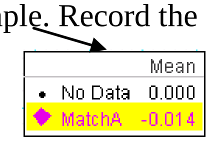
Question Answer on the Data/Question Sheets.
What was the difference in the way you moved to produce the two differently sloped parts (in the first part) of the graph you just matched? What about the slope at the end of the graph?



SAVE this data set (your matching set) on your computer, under a new name.

Part 4 Statistics of the Motion

1. Estimating the average acceleration. Using the SMART TOOL , click in the acceleration graph, and then select a region of the acceleration graph where the acceleration is reasonably constant (or supposed to be). Then use the "summation" tool Σ▾ to display the MEAN value (basically averaging ALL the points in your selection), the information will show up in the legend, for example. Record the mean acceleration on the Data/Question sheets. [Information about how to use the "summation" tool Σ▾ is located in the "store and examine" help page.]



Question Answer on the Data/Question sheet.
How does the magnitude of the mean acceleration for **your motion** compare to the value from the **match** for that same region? (If your velocity curve is roughly similar to the velocity match curve, the acceleration values should be similar.) Explain your answer.

Part 5 Acceleration Graphs - Cart on a Ramp

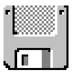
We have experienced our own human-powered velocity and acceleration curves, but it is difficult to maintain a steady acceleration. For a constant acceleration, we will turn to an inclined track and a cart that rolls up and down on it.

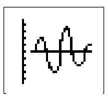
1. Preparation. Set the motion detector on the top end of the track, and clamp it in place. Use the pole and clamp at the end of the track to raise one end--start with a low tilt to the track (about 4-5 cm from the

table). When you start the cart, make sure it is at least 0.5 meters from the detector. Load the file **Lab03_CartTrack.ds** file. Make sure the time axis is set to at least 5 seconds.

2. Graphing the cart rolling down the ramp and speeding up. Let the cart start from rest (0.5 meters from the sensor). Click [▶ Start] and then release the cart when the clicking sound starts. Make sure that the program is graphing **before** you let go of the cart. (Also, make sure the detector doesn't "see" your hands.)

3. Store graphs. Your goal is to find a nice smooth graph of the motion. This means the velocity graph should have a straight-line region, and the acceleration should have a smooth horizontal region. When you have a nice clean curve, name them (such as "low tilt").





4. Higher tilt to track. Increase the tilt of the track a little (a few more centimeters higher at the far end). Perform the experiment again until you get a clean curve. Name this data also (named "high tilt"?).

Low Tilt Graph

5. Finding the average acceleration of the cart from your acceleration graph. Under the [Data ▾] menu on the graph, hide the "high tilt" run (so only the "low tilt" run is visible). Locate a region of the low tilt graph where the acceleration is reasonably constant (a horizontal section of the acceleration curve, or a straight-line portion of the velocity curve). Using the SMART TOOL, identify about 10 values (roughly equally spaced in time) of the acceleration. (Only use values from the portion of the graph after the cart was released and before it hit the end of the track -- during the constant acceleration region.) Record these numbers on the Data/Question sheet, and then calculate the average value of the acceleration.

6. Finding the average acceleration from your velocity graph. You will calculate the slope of your velocity graph (which should be the average acceleration over that interval). Using the SMART TOOL, read the velocity and time coordinates for two typical points on the velocity graph. For a more accurate answer, use two points as far apart in time as possible but still during the time the cart was speeding up (it should be during the straight-line portion of the velocity graph. Record these values on the Data/Question sheet.

7. Find the slope (the average acceleration). Calculate the change in velocity between those two chosen endpoints. Also calculate the corresponding change in time (time interval). Divide the change in velocity by the change in time. This is the average acceleration. Show your calculations on the Data/Question sheet.

8. Calculating the "mean" acceleration. Click in the Acceleration graph, and using the SMART TOOL, select a region of the acceleration graph where the acceleration is constant (basically the same area from which you took the 10 points). Using the [Σ ▾] menu on the graph – display the MEAN value for that data run. Record the mean acceleration of that "low tilt" section on the Data/Question sheet.

Questions Answer these questions on the Data/Question sheet.
a) Is the acceleration positive or negative? Is this what you expected? (Explain your answers.)

b) Does the average acceleration you just calculated agree with the average acceleration you calculated from the acceleration graph? Do you expect them to agree? How would you account for any differences? (Explain your answers.)

High Tilt Graph

9. Find the average acceleration of the cart from your acceleration graph. Hide the "low tilt" run and SHOW the "high tilt" run. Using the SMART TOOL, find 10 values during the constant acceleration region. Then calculate the average value of the acceleration on the Data/Question sheet.

10. Finding the average acceleration from your velocity graph. Calculate the slope of your velocity graph. Using the SMART TOOL, read the velocity and time coordinates for two typical points. Remember to use two points as far apart in time as possible. Record these on the Data/Question sheet.

11. Calculate the average acceleration. Following the steps in Part 5.7, calculate the average acceleration for the "high tilt" portion of the graph.

12. Calculating the "mean" acceleration. Following the steps in Part 5.8, calculate the mean acceleration for the "high tilt" portion of the graph. Record the mean acceleration on the Data/Question sheet.

Questions Answer on the Data/Question sheet.

a) Does the average acceleration calculated from velocities and times agree with the average acceleration you calculated from the acceleration graph, and the mean acceleration from the program? How would you account for any differences? (Explain your answers.)

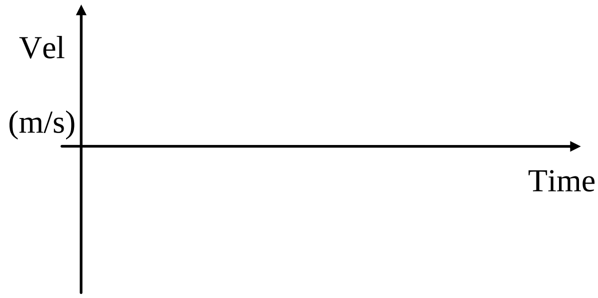
b) Compare this average acceleration to that with the Low Tilt. Which is larger? Is this what you expected? (Explain your answers.)

13. Print the "High/Low" graph. Show both runs (low and high), and print the graph from this section to include with your lab report. (See the printing with DataStudio help page for assistance.)

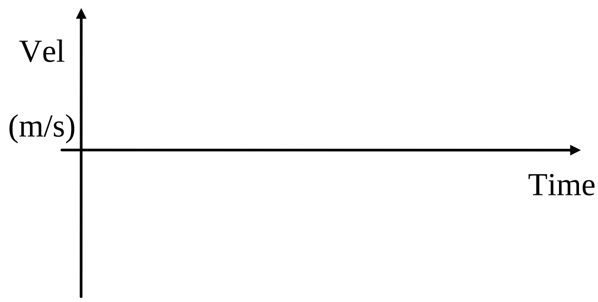
DATA/QUESTION SHEET FOR LAB 3: VELOCITY AND ACCELERATION GRAPHS

Part 1 - Making Velocity-Time Graphs

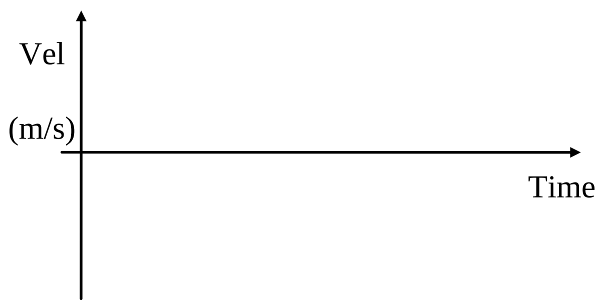
2. Accelerating away. Start at 50 cm from the detector, and walk away from the detector with your speed increasing steadily.



3. Decelerating away. Start at 50 cm from the detector, and begin to walk away quickly and then slow down and stop (speed decreasing steadily).



4. Accelerating toward. Start at 2 m from the detector, and walk toward the detector with a speed that increases steadily.



5. Decelerating toward. Start at 2 m from the detector, and walk toward the detector quickly at first and then slow down steadily and stop (velocity decreasing steadily).

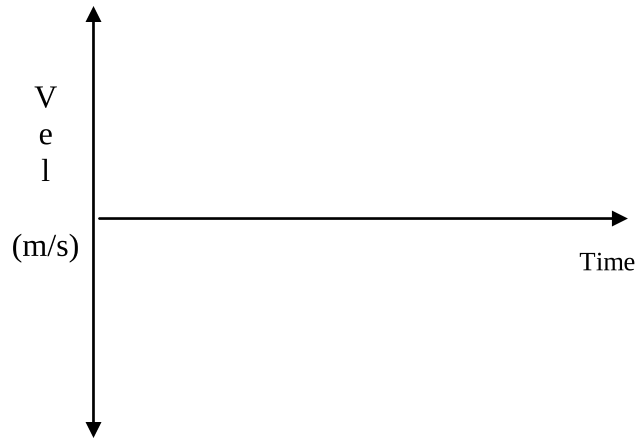
Part 2 - Predicting Velocity-Time Graphs

Prediction Predict the graph produced when a person starts at the 0.5-meter mark, accelerates away from the detector steadily (speed increases) for 4 seconds, then slows down for 6 seconds (deceleration with a smaller magnitude than the acceleration) and stops and then accelerates toward the detector. Draw your prediction on the left graph 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 graph using a solid line. (Do not erase your original prediction.) *Write the prediction **before** performing the experiment.* Points are not taken off for wrong predictions!

PREDICTION

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 graph on the right .

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.

____

____

____

Part 3 - Matching an Existing Velocity-Time Graphs

Question Answer on the Data/Question Sheets.
What was the difference in the way you moved to produce the two differently sloped parts (in the first part) of the graph you just matched? What about the slope at the end of the graph?

____

____

Part 4 Statistics of the Motion

Mean Acceleration from **your motion** = _____________
Mean Acceleration from **match** = _____________

Question How does the magnitude of the mean acceleration for **your motion** compare to the value from the **match** for that same region? (If your velocity curve is roughly similar to the velocity match curve, the acceleration values should be similar.) Explain your answer.

____

____

____

Part 5 Acceleration Graphs - Cart on a Ramp

Low Tilt Graph

5. Finding the average acceleration of the cart from your acceleration graph. (Only use values from the portion of the graph after the cart was released and before it hit the end of the track -- during the constant acceleration region.)

Accelerations from graph (m/sec^2): _____ _____ _____ _____ _____ (These values should be
_____ _____ _____ _____ _____ very similar!)

Average acceleration (mean): ________m/sec^2 **(Low Tilt)**

7. Find the slope (the average acceleration) between two points on the velocity graph.

Point 1 Velocity _______ m/sec Time ________ sec
Point 2 Velocity _______ m/sec Time ________ sec

Change in velocity: _______ m/sec Change inTime: _______ sec

Average acceleration: _______ m/sec^2 **(Low Tilt)**

8. Calculating the "mean" acceleration.

Mean acceleration = __________ m/sec^2

Questions a) Is the acceleration positive or negative? Is this what you expected? (Explain your answer.)
____
____

b) Does the average acceleration you just calculated agree with the average acceleration you calculated from the acceleration graph? Do you expect them to agree? How would you account for any differences? (Explain your answer.)
____
____

High Tilt Graph

9. Finding the average acceleration of the cart from your acceleration graph.

Accelerations from graph (m/sec^2): _____ _____ _____ _____ _____ (These values should be
_____ _____ _____ _____ _____ very similar!)

Average acceleration (mean): ________m/sec^2 (High Tilt)

10. Finding the average acceleration from your velocity graph.

Point 1	Velocity	_______	m/sec	Time	________	sec
Point 2	Velocity	_______	m/sec	Time	________	sec

11. Calculate the average acceleration.

Change in velocity: _______ m/sec Change in Time: _______ sec

Average acceleration: _______ m/sec^2 (High Tilt)

12. Calculating the "mean" acceleration.

Mean acceleration = __________ m/sec^2

Questions a) Does the average acceleration calculated from velocities and times agree with the average acceleration you calculated from the acceleration graph, and the mean acceleration from the program? How would you account for any differences? (Explain your answer.)

____

____

b) Compare this average acceleration to that with the Low Tilt. Which is larger? Is this what you expected? (Explain your answers.)

____

____

Return equipment to instructor and to the box from where you have removed it. Please insure a good experience for the next lab group by cleaning up your lab station.

How do I write up this lab? … What is required for this lab report?

Consult the Rubric at the end of this manual for this experiment and the "Lab Report Instructions" document on the Lab Schedule page.

.

Questions/Suggestions -> Dr. Changgong Zhou – czhou@ltu.edu

Portions of this laboratory manual have been adapted from materials originally developed by Priscilla Laws, David Sokoloff and Ronald Thornton for the Tools for Scientific Thinking, RealTime Physics and Workshop Physics curricula. You are free to use (and modify) this laboratory manual only for non-commercial educational uses.

Lawrence Technological University
Department of Physics

College/University Physics 1 Lab
PHY2221/PHY2421

Rubric - Lab 3 Velocity and Acceleration Graphs - 80 points

Cover Page	Student Name	1
5 Points	Course-Section-Station	1
	Lab Title / Instructor's Name	1
	Date / Lab partner names	1
	HONOR CODE PLEDGE	1

Introduction	Content/Grammar/Spelling	10
10 Points		

Part 1 – Making Velocity -Time graphs	Sketches (D/Q)	8
8 Points		

Part 2 – Predicting Velocity -Time graphs	Sketches (D/Q)	6
10 Points	Question (D/Q)	4

Part 3 – Matching Velocity - Time graph	Question (D/Q)	4
4 Points		

Part 4 – Statistics of the Motion	Calculations (D/Q Show Sample Calculations)	4
8 Points	Question (D/Q)	4

Part 5 Acceleration Graphs – Cart on a ramp		
20 Points	**Low Tilt** - Calculations / Questions (D/Q)	4 / 4
[Show sample of high tilt calculation in Report]	**High Tilt** - Calculations / Questions (D/Q)	4 / 4
	High - Low – Graph	4

Analysis (1)	Spelling/Grammar	5
15 Points	Connection between motion and graph representations	10

(1)
Analysis – write 1-2 relevant paragraphs analyzing the results of this experiment following the requirements in "Lab Report Instructions" on the website. Include a description of how a specific motion is displayed on the two graphs (that is, "if the velocity is this way, the acceleration graph looks like this"). (See "Lab Report Instructions" file for format details.)

Also: points will be taken off for the following as appropriate:

- Report turned in late (5 points per school day)
- Any units missing (if not printed on data table) (1 pt each)
- Report not typed/stapled (5 pts)
- Decimal point and sig fig errors (1 pt each)
- Presentation (i.e. torn edges on papers (5 pts)
- **Instructor's signature/stamp missing – 5 points**
- **Data/Question sheets missing – 20 points**

Revised – 2/3/2012