Motion in One Dimension
Introduction to Motion in 1D

Three types of graphs can be used to represent the motion of an object in one dimension. Those are: position vs. time (x vs. t), velocity vs. time (v vs. t) and acceleration vs. time (a vs. t).

Remember that:

• for \( x \text{ vs } t \) graphs
  - slope (of a tangent) = instantaneous velocity
• for \( v \text{ vs } t \) graphs
  - slope (of a tangent) = acceleration
  - area under the graph = displacement

We will study two kinds of motion with constant acceleration:

1. constant zero acceleration i.e. constant velocity.
2. constant non-zero acceleration i.e. changing velocity.
Introduction

The goals of this experiment are:

- To learn how to use an ultrasonic motion detector and Logger Pro to collect and analyze position vs time data.
- To learn how different types of motion are represented graphically and to observe a relationship between graphs of position vs time (x vs t), velocity vs time (v vs t) and acceleration vs time (a vs t).
- To learn how to interpret those graphs and extract useful information about the motion from them.
Equipment

The ultrasonic motion detector is a device which measures a distance to an object by sending out an ultrasonic pulse and determining the time for the reflected pulse to come back. It needs to be connected to a computer via a LabPro interface as shown in the picture to the right. The LabPro needs to be plugged in into the power outlet.

Be Aware – the motion detector can only measure distances in a range from 0.15 m to 6.0 m. Make sure that your paddle is always in that range during the experiment.
Experimental Setup

- Connect the motion detector with the LabPro using USB cable provided. Use DIG/SONIC 1 port (see picture on previous slide).
- Stand the detector upright and facing you approximately 50 cm away from the edge of your bench (see image below).
Part II B: Constant Velocity

Open LoggerPro and download the synthetic position vs. time data by clicking on the image to the right.

QUESTION 1: What are the initial and final positions of the object?

QUESTION 2: How does the velocity of the object change during its motion?

For answer to QUESTION 2 use expressions like: “constant velocity”, “negative acceleration”, “zero velocity”, “moves forward”, “moves backwards”, etc. Be specific about time intervals involved. For example: “the object then moves forward at constant velocity for 1 second”
Data collection \((x \ vs. \ t\ \text{graph})\)

Try to reproduce the position vs time graph by doing the following:

- Place the wooden paddle at the \textit{initial position} as read in the data table.
- Begin data acquisition by clicking \textbf{“Collect”} button at the top of the main LoggerPro window.
- Data collection starts when the motion detector starts making the faint clicking sound.
- move the paddle in a way so that the data you collect, overlap as closely as possible the synthetic data graph.
- If you are not satisfied with your data, simply click the \textbf{“Collect”} button and try again. The new data will overwrite the one shown on the screen.

\textbf{Both you and your partner should practice data collection now. DO NOT print the resulting graphs.}
Few more tries

- Make several attempts to improve your graph. You can use Undo/Redo button to go back and forth between current and previous graph.

**DO NOT GET FRUSTRATED! Have some fun. After 10 tries consult with one of the lab instructors.**

- Once you have your graph which looks reasonable double click anywhere on the white area of it and change its title to: “Position vs. time Graph 1”.

Save your LogerPro file to the Desktop by clicking “File” and then “Save As” option in the main menu.

Give your file a name and make sure that you choose “Desktop” in the “Where” field.
QUESTION 3: With reference to the synthetic position vs. time data, what do the segments before 1s and after 4s look like?

QUESTION 4: How can you be sure that this synthetic position versus time graph represents constant ZERO acceleration? i.e. How is the velocity (i.e. its slope) changing?
QUESTION 5: Consider the horizontal segment of your v vs. t graph (synthetic data) between 1s and 4s. Does it correspond to constant zero acceleration? Explain.

QUESTION 6: Were you able to reproduce the synthetic v vs t data accurately?
Interpreting your a vs. t graph

**QUESTION 7:** Consider the horizontal segment of your a vs. t graph (synthetic data) between 1s and 4s. Does it represent constant zero acceleration? Explain. Comment on how well your data agrees with the synthetic data.

**QUESTION 8:** In the synthetic acceleration vs. time graph, what do the spikes at 1s and 4s represent physically?
Preparing your graphs

In LoggerPro:

Click **Page** and then **Auto Arrange**.

Examine your graphs carefully. If any graph data falls outside the range of your axes, you can fix this by using **Autoscale**. Click on the graph to select it and then click the blue **A** in the toolbar.

Your graphs also need titles. Double click the top graph and in the dialogue box that comes up select **Graph Options**. Enter the title:

Graph 1: Position vs. time.

Similarly title the other graphs as:

Graph 2: Velocity vs. time.
Graph 3: Acceleration vs. time.
Printing Graphs

Print your three graphs in a landscape orientation by following these steps:

Click **File** and then **Page Setup**.
Select the **Landscape** orientation and **OK**.

Go to **File** and **Print**.
Enter your names in the **Print options** dialog box.
Click **Print**.
Part II C: Changing Velocity

- Download **new** synthetic position vs. time data for an object moving at constant non-zero, positive acceleration by **clicking on the image to the right**.
- Try to reproduce it with your paddle, as best you can.
- Save your LoggerPro file on the desktop.

- Autoscale as needed and title the graphs as before but the graph numbers will now be 4, 5 and 6.
Interpreting Your Results

Refer to your second set of graphs to answer questions 9 – 11.

**QUESTION 9:** How can you be sure that this position vs. time graph represents motion with positive acceleration? i.e. How is the velocity (slope of this graph) changing?

**QUESTION 10:** Sketch a velocity vs. time graph for constant positive acceleration? Does the synthetic data graph represent this?

**QUESTION 11:** Sketch an acceleration vs. time graph for constant positive acceleration. Does the synthetic data represent this?

Print your second set of graphs by following the same steps as before.
QUESTION 12: On the set of axes in your lab workbook, sketch the graphs of position vs. time, velocity vs. time and acceleration vs. time for the motion of an object which is thrown straight up and returns to the hand.
Finishing Up

- Close all applications and logout.
- Tidy your workspace and slide your lab stool under the bench before you leave.
- Place your lab book on the appropriate shelf.
- Sign your name on the sign out sheet by the door.

Don’t forget to include your printed graphs in your report!!
Don’t forget to include a signed copy of your prelab in your report!!