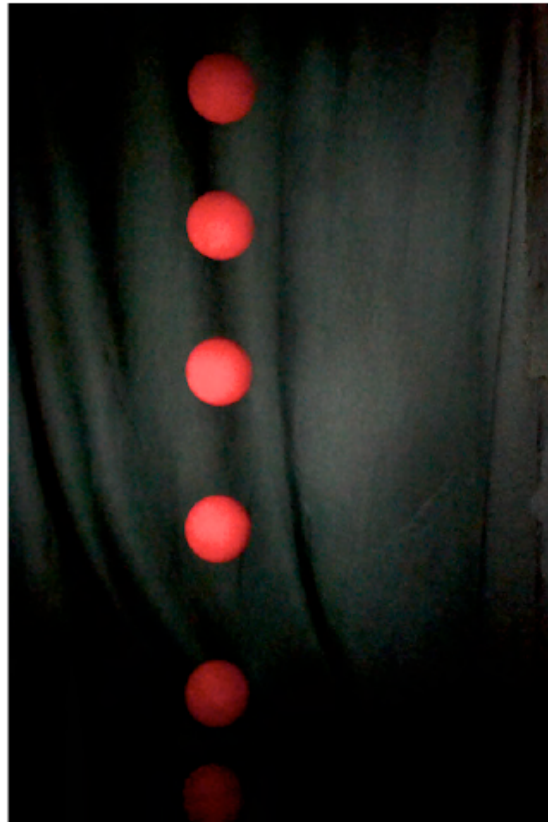


Motion in One Dimension



Introduction to Motion in 1D

In this experiment you will be investigating the motion of an object in one dimension. You will be attempting to reproduce synthetic position versus time graphs by moving an object to see what graphs of the motion should look like. You will also be investigating how to find information about the position, velocity, and acceleration from position versus time, velocity versus time, and acceleration versus time graphs.

Position

Position in one-dimensional motion is usually given by the symbol x . Position has unit of length (e.g. meters), it may be positive or negative and is measured relative to a coordinate system.

Displacement is the change in position and is a vector,

$$\Delta\vec{x} = \vec{x}_f - \vec{x}_i$$

Where \vec{x}_i is the initial position and \vec{x}_f is the final position.

Introduction to Motion in 1D

Velocity

Velocity is a vector which shows the direction and rate of motion. The standard unit of velocity is meter per second.

The average velocity of an object is the total displacement during some extended period of time, divided by that period of time,

$$\vec{v} = \frac{\Delta \vec{x}}{\Delta t}$$

Instantaneous velocity describes the motion of a body at one particular moment in time. It can be found by calculating the slope of a line that is tangent to the object's *Position* versus *Time* graph at that time.

Speed and velocity are *not* the same thing: speed is a scalar, whereas velocity is a vector. One must use different rules when combining speeds and combining velocities.

Introduction to Motion in 1D

Acceleration

Acceleration is a vector which shows the direction and magnitude of changes in velocity. Its standard units are meters per second per second, or meters per second squared.

Average acceleration is the total change in velocity (magnitude and direction) over some extended period of time, divided by the duration of that period.

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

Instantaneous acceleration is the rate and direction at which the velocity of an object is changing at one particular moment. It can be found by calculating the slope of the object's *Velocity* versus *Time* graph.

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 vs t graphs

slope (of a tangent) = instantaneous velocity

for v 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.

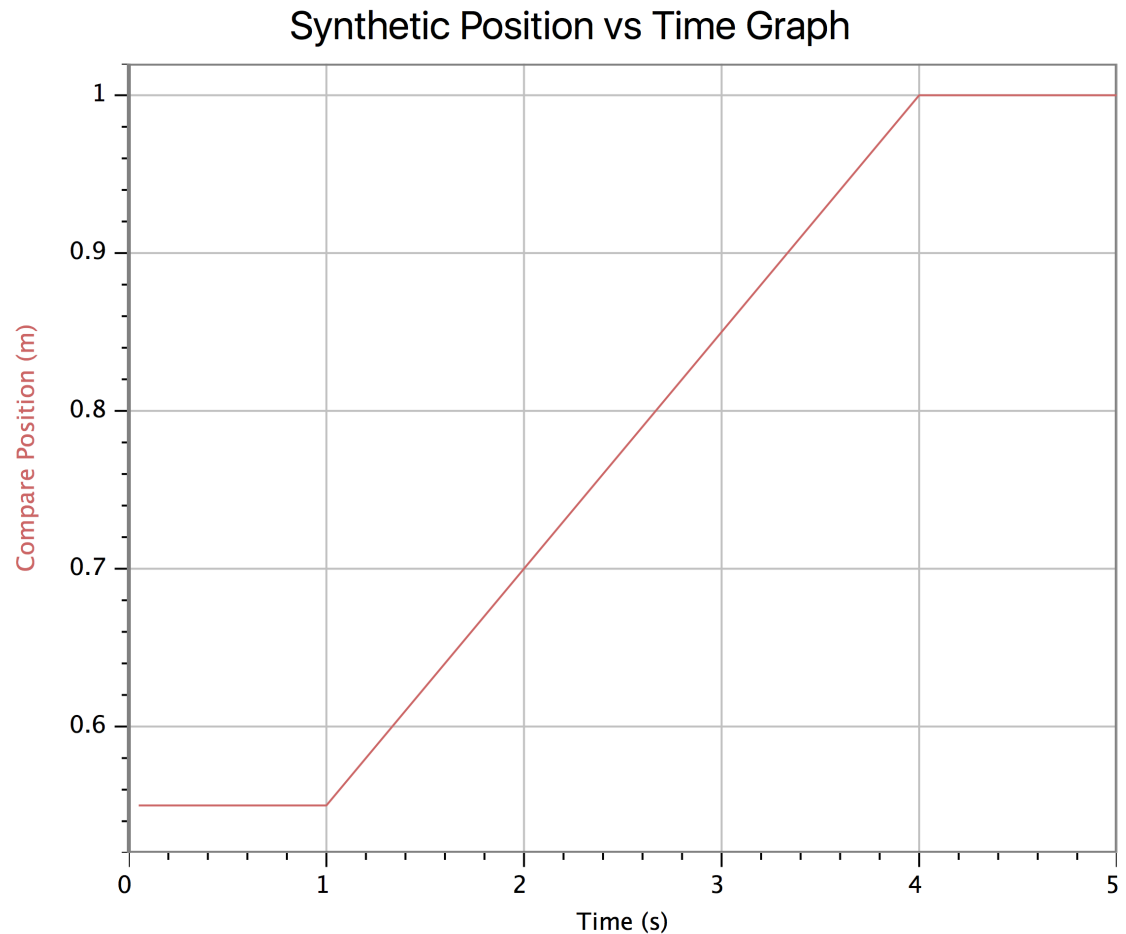
Objectives

The objectives 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.

Part II A: Interpret Synthetic Graph

Refer to the right synthetic position vs time graph, please answer Questions 1 to 4.



Part II A: Interpret Synthetic Graph

Q

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

Q

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”

Q

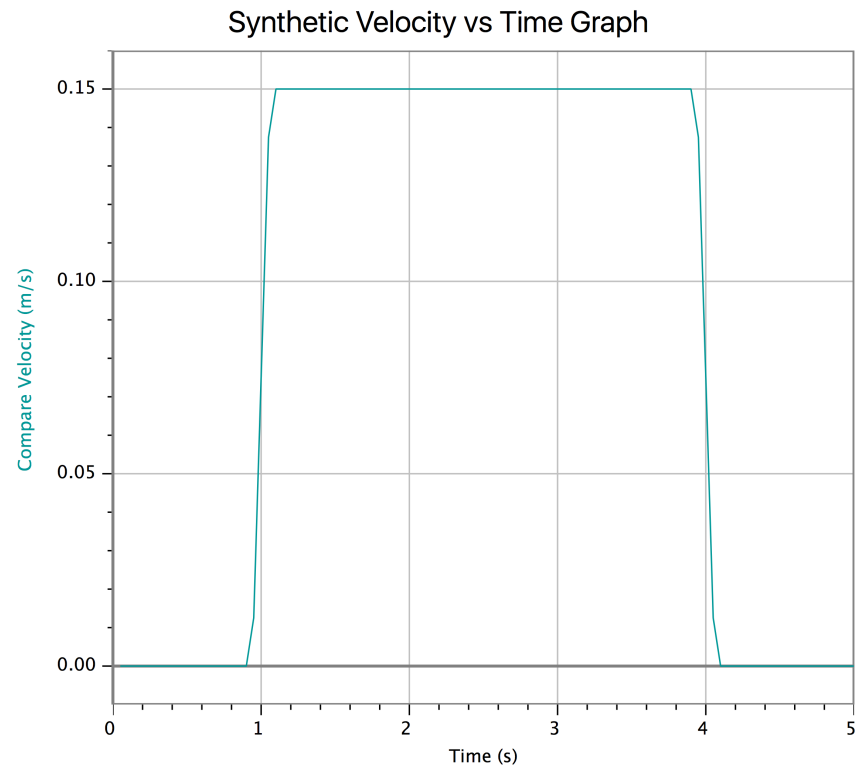
QUESTION 3: With reference to the synthetic position vs. time graph, what do the segments before 1s and after 4s look like?

Q

QUESTION 4: Look at the middle section of the synthetic x vs. t graph after 1 s and before 4 s. How can you be sure that this section represents constant ZERO acceleration? Think about how the velocity (i.e. the slope) is changing

Part II A: Interpret Synthetic Graph

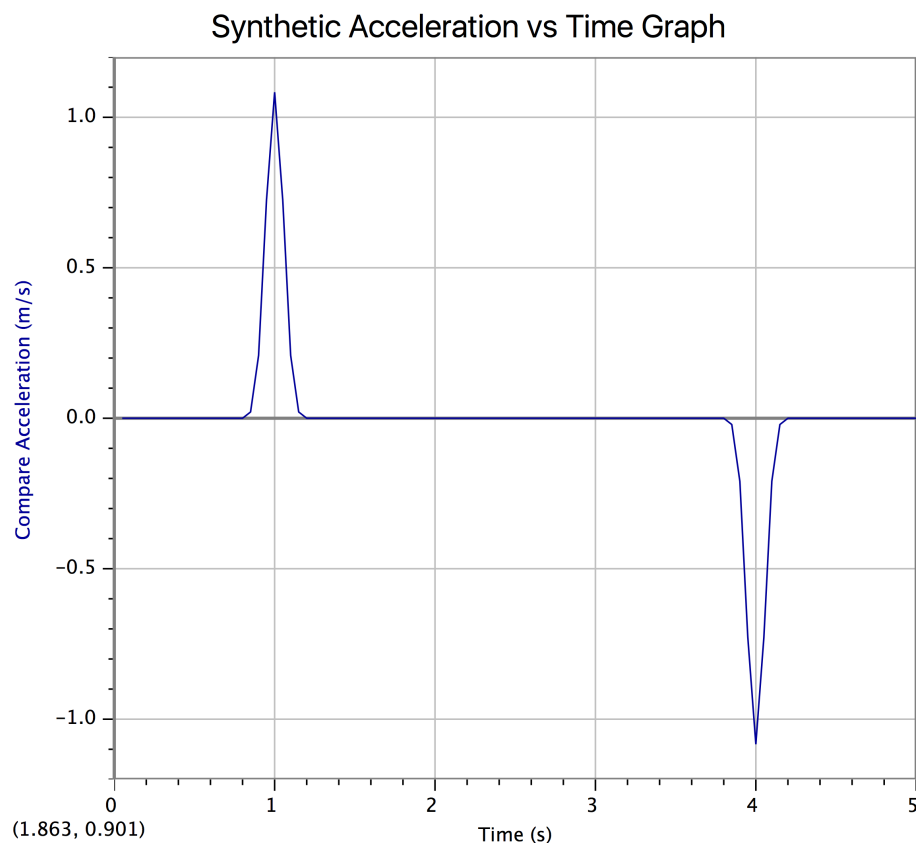
Refer to the right synthetic velocity vs time graph, please answer Question 5.



QUESTION 5: Consider the horizontal segment of the synthetic velocity vs. time graph between 1s and 4s. Does it correspond to constant zero acceleration? Explain.

Part II A: Interpret Synthetic Graph

Refer to the right synthetic acceleration vs time graph, please answer Questions 6 & 7.



Part II A: Interpret Synthetic Graph

Q

QUESTION 6: Consider the horizontal segment of the acceleration vs. time graph between 1s and 4s. Does it represent constant zero acceleration? Explain.

Q

QUESTION 7: In the synthetic acceleration vs. time graph, what do the spikes at 1s and 4s represent physically?

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 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.



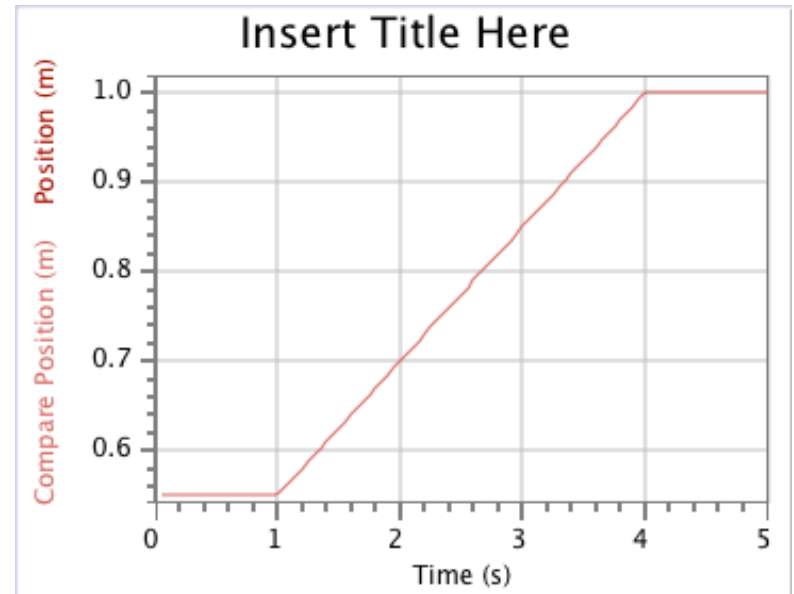
Experimental Setup

- 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.



Data collection (x vs. t graph)

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

- Place the wooden paddle at the **initial position** as found in Question 1.
- Begin data acquisition by clicking “**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 “**Collect**” button and try again. The new data will overwrite the one shown on the screen.

**Both you and your partner should practice data collection now.
DO NOT print the resulting graphs.**

Few more tries

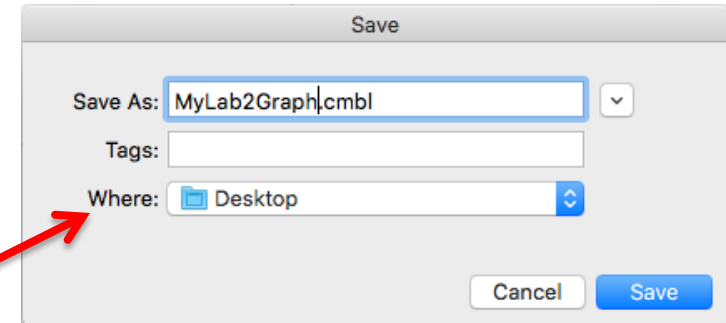
- Make several attempts to improve your graph. You can use Undo/Redo button to go back and forth between current and previous graph.

DO NOT GET FRUSTRATED! Have some fun. If you have not succeeded 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: “Graph 1: Position vs. time”.

Save your LoggerPro 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.



Interpreting Your Own Graphs

Q

QUESTION 8: Were you able to reproduce the synthetic x vs. t , v vs. t , and a vs. t data accurately? Comment on how well your data agrees with the synthetic data.


CP

Have your instructor check your graphs and initial your lab book in the box provided !!

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  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

P

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

Click **File** and then **Page Setup**.

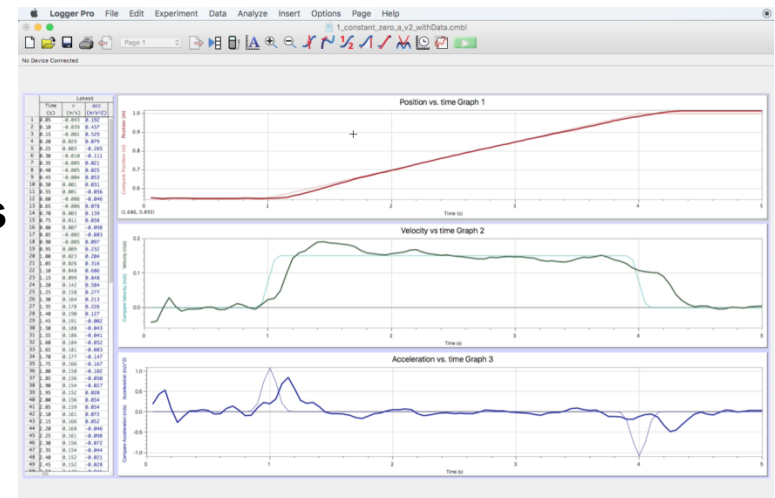
Select the **Landscape** orientation and **OK**.



Go to **File** and **Print**.

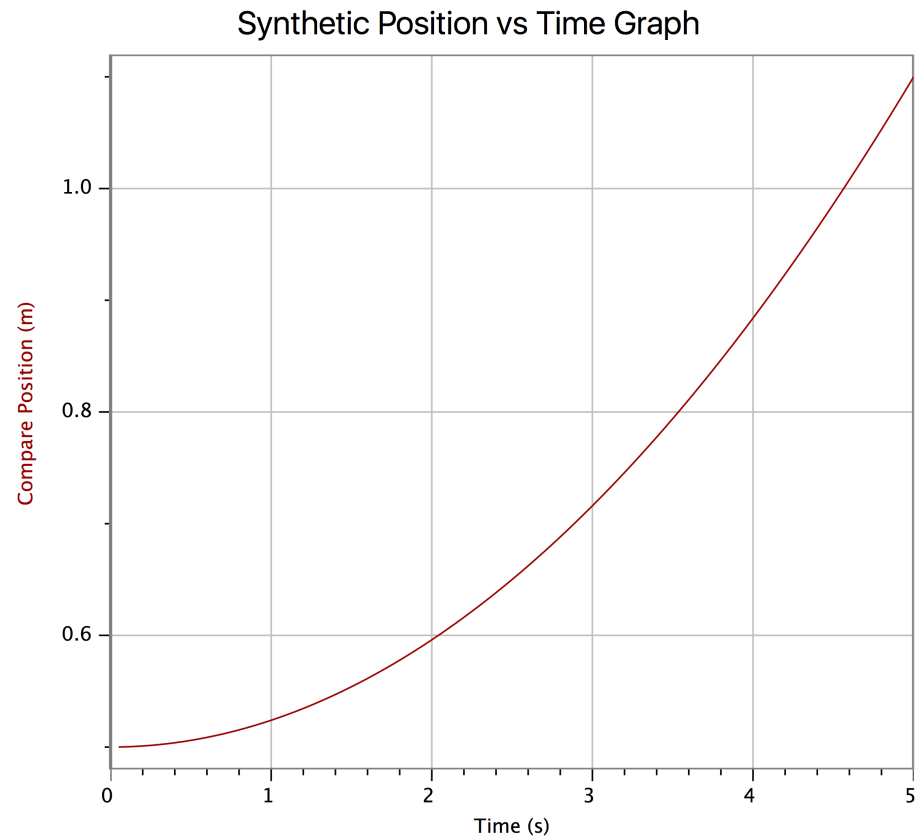
Enter your names in the **Print options** dialog box.

Click **Print**.



Part II C: Changing Velocity

Refer to the right synthetic position vs time graph, please answer the Questions 9 to 11.



Part II C: Changing Velocity

Q

QUESTION 9: Explain how the **position vs. time** graph represents motion with positive acceleration. HINT: What does the slope of position vs. time represent?

Q

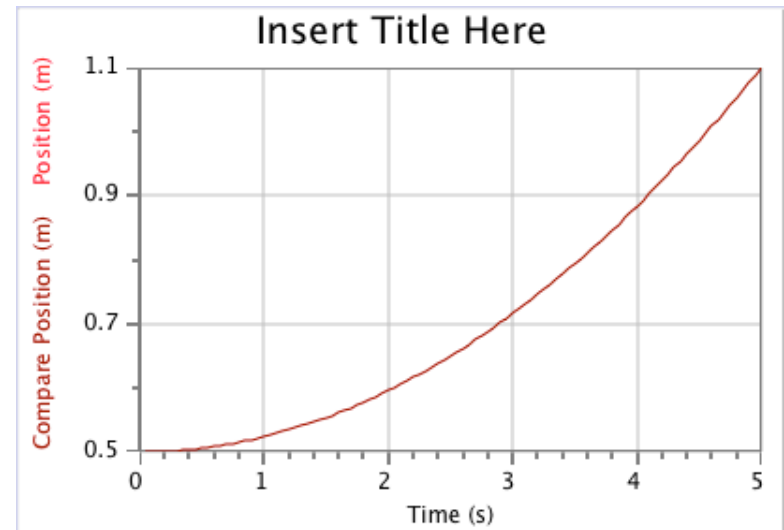
QUESTION 10: Sketch a **velocity vs. time** graph for constant positive acceleration. What does the slope represent?

Q

QUESTION 11: Sketch an **acceleration vs. time** graph for constant positive acceleration.

Part II C: Changing Velocity & Data Collection

Download **new** synthetic position vs. time for an object moving with a constant positive acceleration by clicking on the image to the right.



- Now try to reproduce the graph with your paddle.
- 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.
- **Print your second set of graphs by following the same steps as shown on page 20-21.**

Summary

Q

QUESTION 12: On the set of axes provided in your lab workbook, sketch the three graphs for motion with constant **negative** acceleration.

Give an example of negative acceleration in one dimension?

- 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 !!