Lab 3 Motion in One-Dimension Part 1: Position and Velocity, Intro to Graphical and Statistical Analysis

Objectives:

- To obtain an understanding of position and velocity for one-dimensional motion
- To understand how graphs can be used to describe changes in position and velocity of an object moving along a straight line
- To be able to interpret and produce graphs of position and velocity
- To understand and be able to use graphical and statistical methods to determine the average velocity from both position and velocity graphs

Equipment

- Computer
- LabPro computer interface
- Motion detector
- Real-Time physics mechanics experiment configuration files (software)
- White board

Exploration 1. Exploring position vs. time graphs of your motion

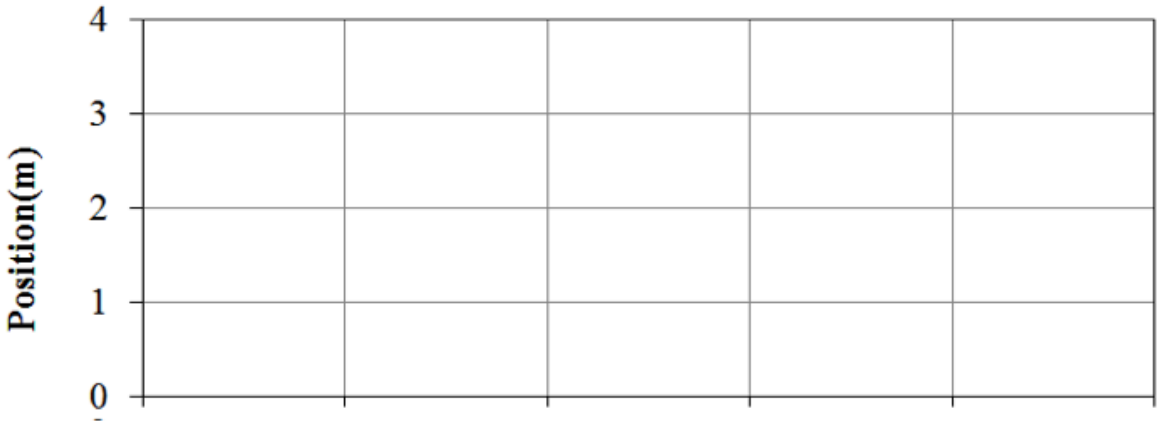
An ultrasonic motion detector is a device that can be used to record an object's motion as a function of time. It sends out a series of sound pulses (too high frequency to hear). These pulses reflect from objects in the vicinity and the reflected pulses return to the sensor. The computer can record the time it takes the reflected pulses to return to the computer, and using the speed of sound, calculate the position of the object.

When using a motion sensor:

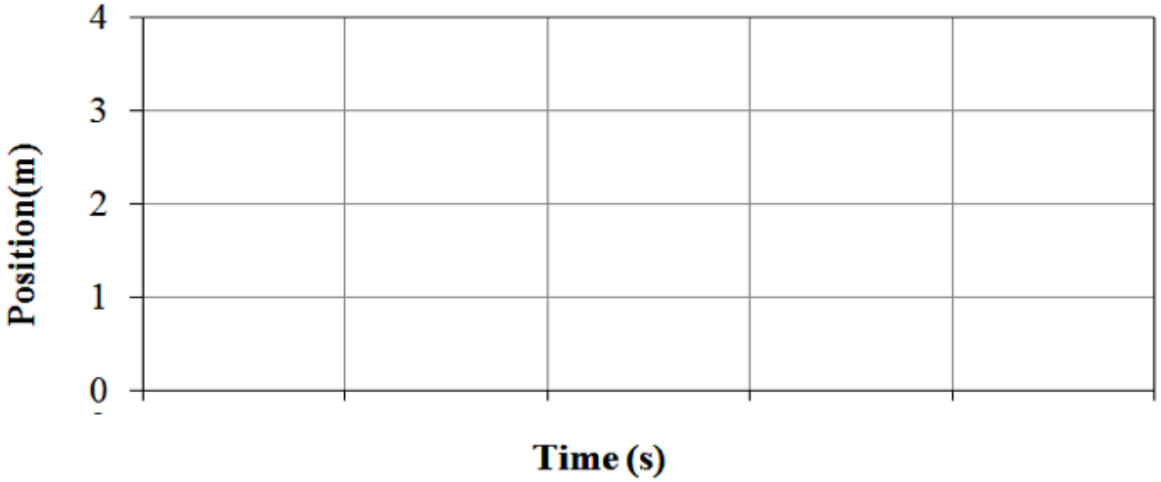
1. The motion detector will not correctly measure anything closer than a 0.15m or further than 6.0m. The object must be further than 0.10m or closer than 5.0m from the sensor in order to get good data.
2. The ultrasonic waves spread out in a cone of about 15° as they travel. They will "see" the closest object. Be sure there is a clear path between the object whose motion you want to track and the motion sensor.
3. The motion sensor is very sensitive and will detect slight motions. You can try to glide smoothly along the floor, but don't be surprised to see small bumps in position graphs and even larger bumps later in velocity and acceleration graphs.
4. Some objects like bulky sweaters are good sound absorbers and may not be "seen" very well by a motion sensor. You may want to hold a book in front of you if you have loose clothing on.

Exploration 1.1 Predict and sketch position vs. time graphs for the following situations:

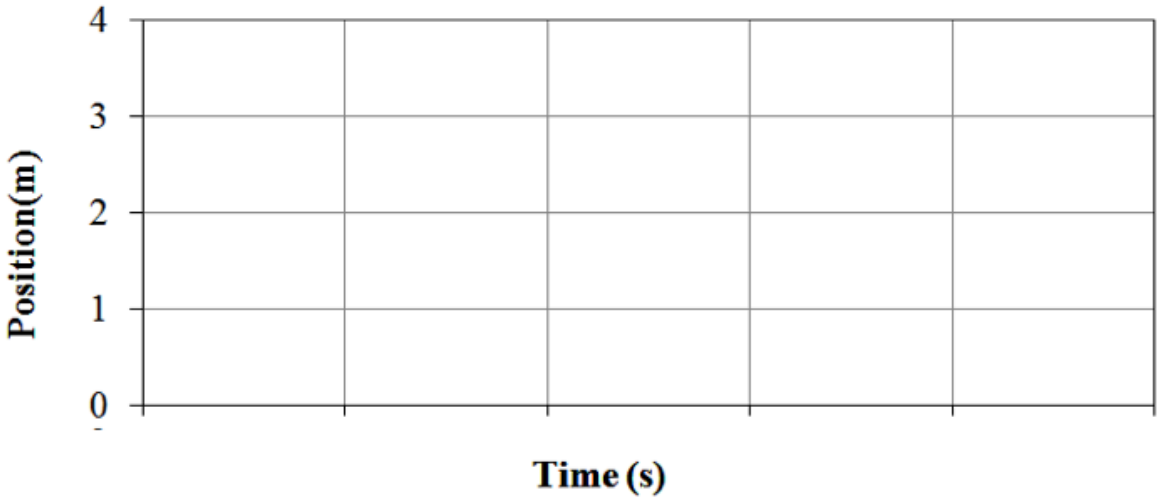
- standing still
- starting near the detector, walking at a fast steady walking speed away from the detector
- walking at a slow steady walking speed away from the detector, then walking at a fast steady walking speed further away from the detector
- standing about 3m away from the detector, walking at a slow steady walking speed towards the detector, stopping briefly, then walking at a fast steady walking speed towards the detector



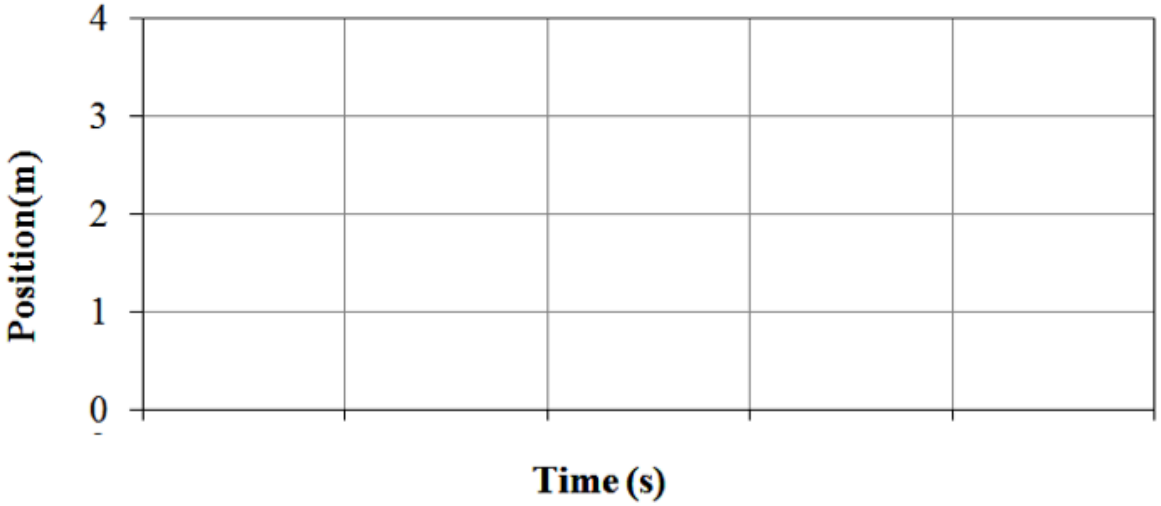
standing still



walking steady, fast away from the detector



walking steady, slow away, then steady fast further away



start 3m away, walk steady slow towards, stop briefly, walk steady fast towards

Exploration 1.2

Connect the computer to the LabPro interface with a USB cable and the motion detector to the DIG/SONIC2 port on the LabPro with a British Telecom cable. Connect the power cord to the AC adapter port on the LabPro computer interface and plug it in. Open the experiment file "**Distance (L01A1-1a)**" on the computer to display position versus time axes.

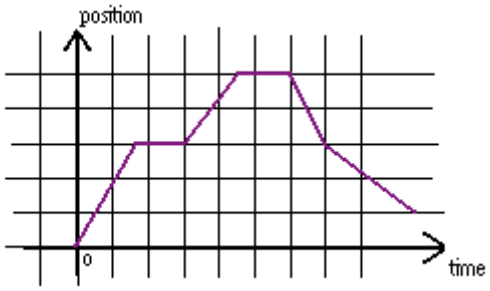
Set the motion detector where you have an aisle in front of the detector about 5m long and 1.5m wide. Perform the motions described in Exploration 1.1 in front of the motion detector while taking data.

Save each of the graphs using the store command.

Compare the graphs to your predictions.

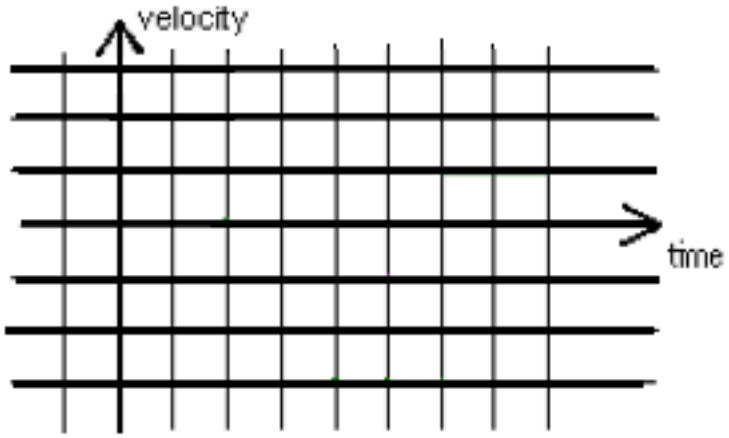
Exploration 1.3

Test your graph interpretation skills by walking in front of the motion detector to create the following graph:



Exploration 1.4

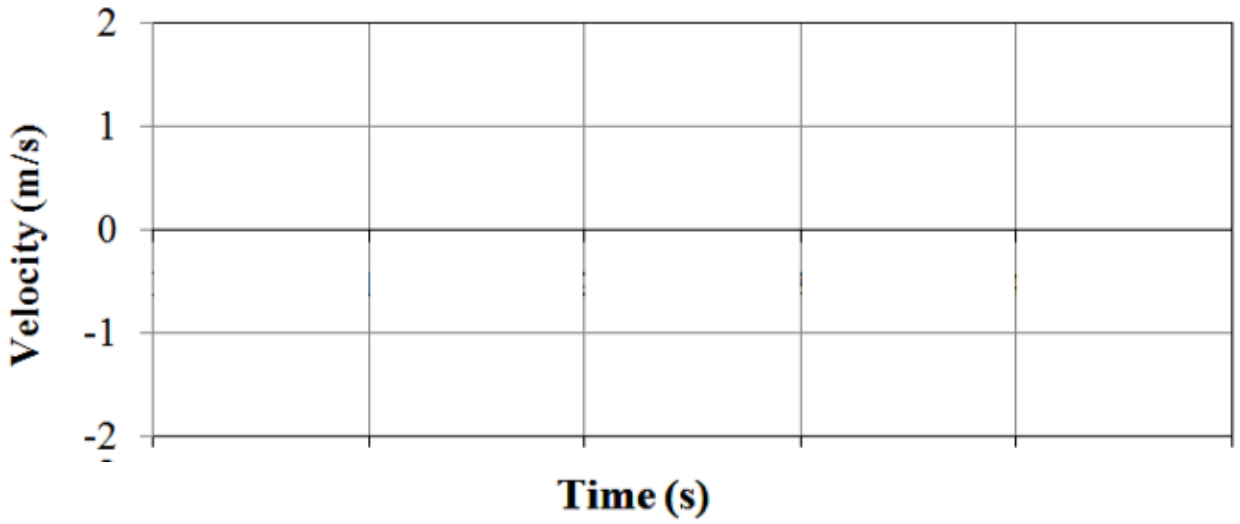
Draw a graph of velocity vs. time that corresponds to the motion illustrated in Exploration 1.3. Explain why you drew the graph the way you did.



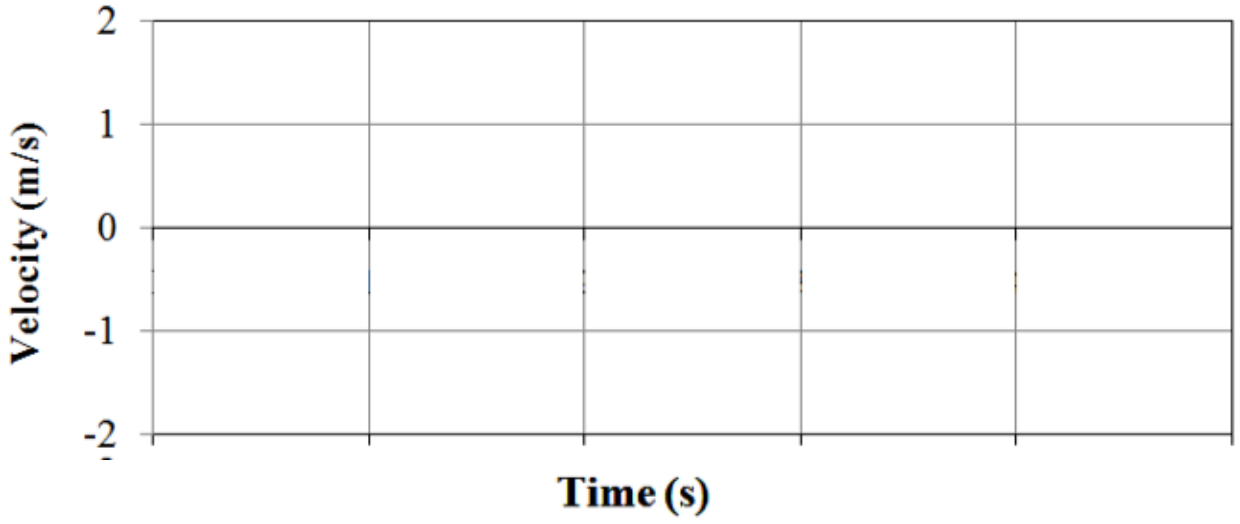
Exploration 2. Velocity vs. time graphs of motion

2.1 Predict and sketch velocity vs. time graphs for the following situations:

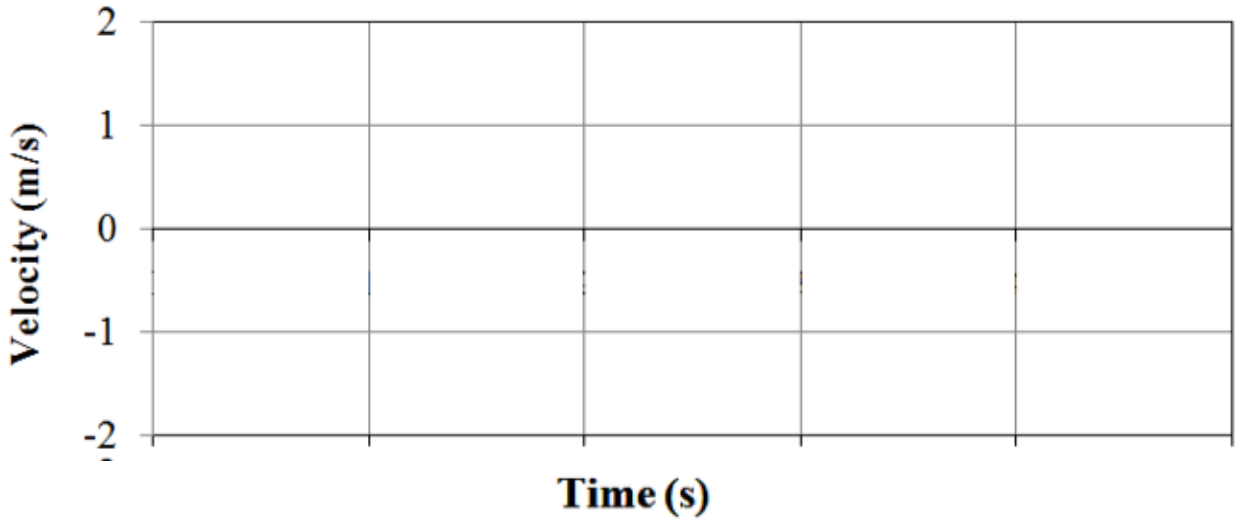
- standing still
- starting near the detector, walking at slow, steady speed away from the detector
- starting away from the detector, walking at a fast speed towards the detector
- standing 3m away from the detector, walking at a slow constant speed towards the detector, stopping briefly, walking at a fast constant speed away from the detector



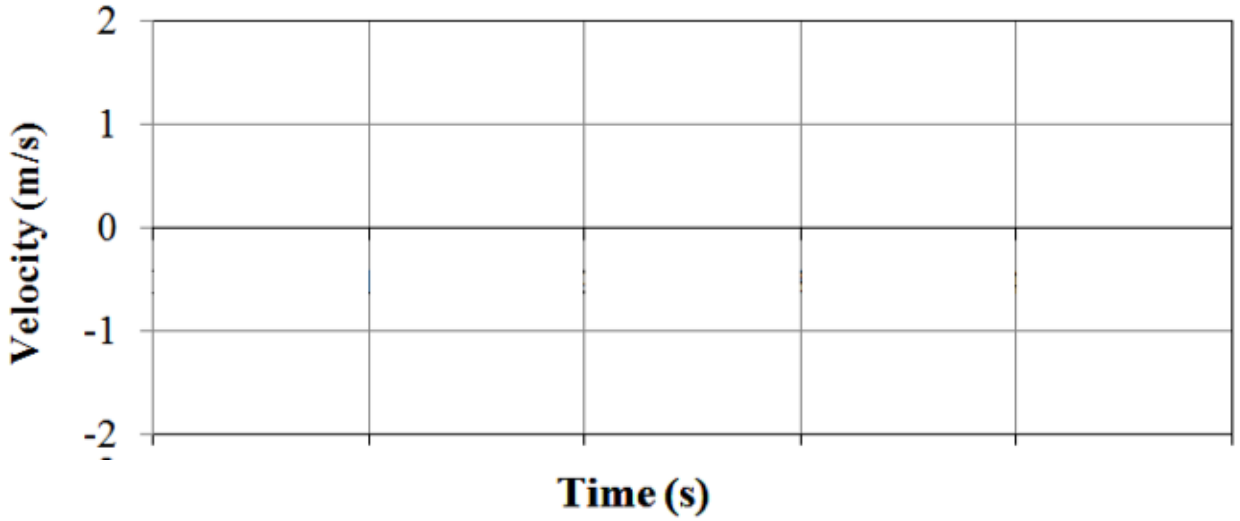
standing still



walk at a slow, steady speed away from detector



walk fast, steady speed toward detector



start 3m away, walk slow, steady speed towards, stop briefly, walk fast, steady speed away

2.2 Open the experiment file "**Velocity Graphs (L01A2-1)**" to set up velocity vs. time axes.

Perform each of the motions described in Exploration 2.1 in front of the motion detector while taking data.

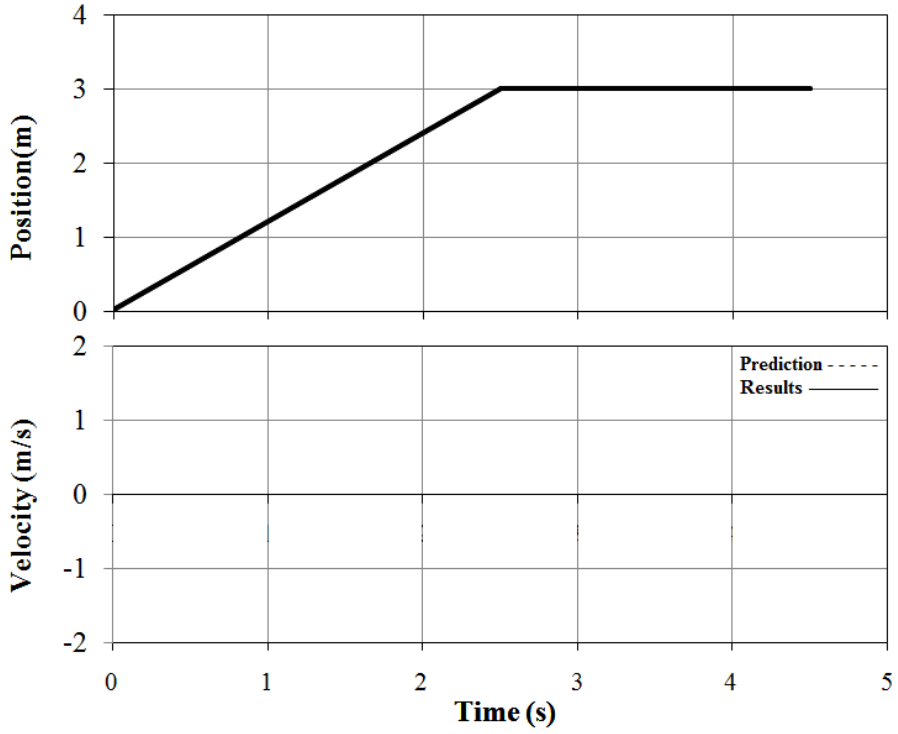
Save each of the graphs using the store command.

Compare the graphs to your predictions.

2.3 How are velocity graphs related to position graphs? Explain.

Exploration 3. Predicting velocity graphs from position graphs

3.1 For the graph below, predict the velocity graph that corresponds to the position graph. Sketch your prediction on the velocity-time graph.



3.2 Open the experiment file "**Velocity from Position (L01A3-1)**" to set up position vs. time and velocity vs. time axes.

Test your prediction. Save the graphs using the store command.

Compare the graphs to your predictions.

Investigation 1 Average velocity

Investigation 1.1 For the data in Exploration 3, use the *Examine* feature under *Analyze* in the software to extract 10 values of the velocity within the time period (0-2.5s), and fill in the table below. Then calculate the average velocity ($\bar{v}$).

i	v_i (m/s)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
$\bar{v} = \frac{\sum_{i=1}^{N} v_i}{N} =$	

Average velocity = _____

Investigation 1.2 The average velocity can also be calculated from the slope of the position graph. Use the *Examine* feature of the software to read the position and time coordinates for two typical points as far apart as possible in the time period (0-2.5s) and record the results below. Calculate the average velocity from the slope of your position vs. time graph using this information.

	Position (m)	Time (s)
Point 1		
Point 2		
Change in position (m) =		
Time interval (s) =		
Average velocity (m/s) =		

Investigation 1.3 Does the average velocity you just calculated from the position graph agree with the average velocity you found from the velocity graph? Explain

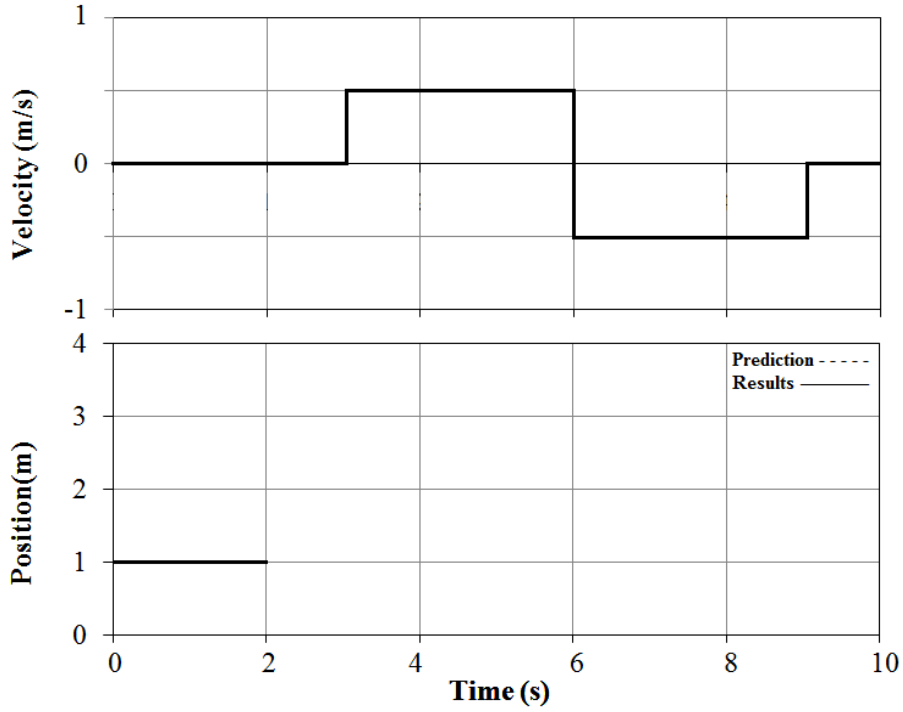
Investigation 1.4 There are two other ways to use the software to determine the average velocity from the velocity graph.

Investigation 1.4.a To find the average (mean) value of the velocity, use your mouse to select a portion of the velocity vs. time graph for which you want to find the mean value. Then use *Statistics* under *Analyze* to determine the minimum, maximum, mean, median, and standard deviation of the values in that portion of the graph. How does this value compare to the two previous values you found for the average velocity?

Investigation 1.4.b You can also find the average value of the velocity from the position graph using a fitting routine. Use your mouse to select a portion of the position graph for which you want to find the slope. Then use *Linear Fit* under *Analyze* to find a best fit line, including the slope and the intercept. How does this value compare to the three previous values you found for the average velocity?

Exploration 4. Predicting position graphs from velocity graphs

Exploration 4.1 Study the following velocity-time graph and predict the position-time graph. Sketch your prediction on the graph below.



Exploration 4.2 After sketching your prediction, do your best to duplicate the top (velocity-time) graph by walking in front of the motion detector. Save the graphs using the store command.

Compare the graphs to your predictions.