

Lab 1: One Dimensional Motion

Materials:

Track

Motion Sensor – Place motion sensor on the zero of the track. (Always put the yellow plug from the sensor in the digital channel of the interface box with the lower number. The yellow plug carries the transmit signal and the black carries the return echo signal.)

Cardboard or Foam board

850 Interface

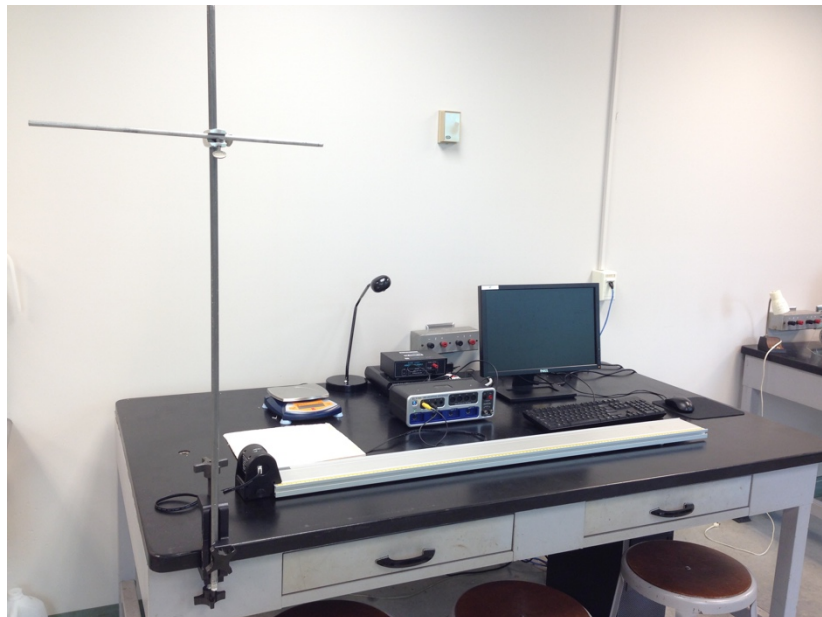
Capstone

Post it flags

Clamp & Rods

Basketball/ soccer ball

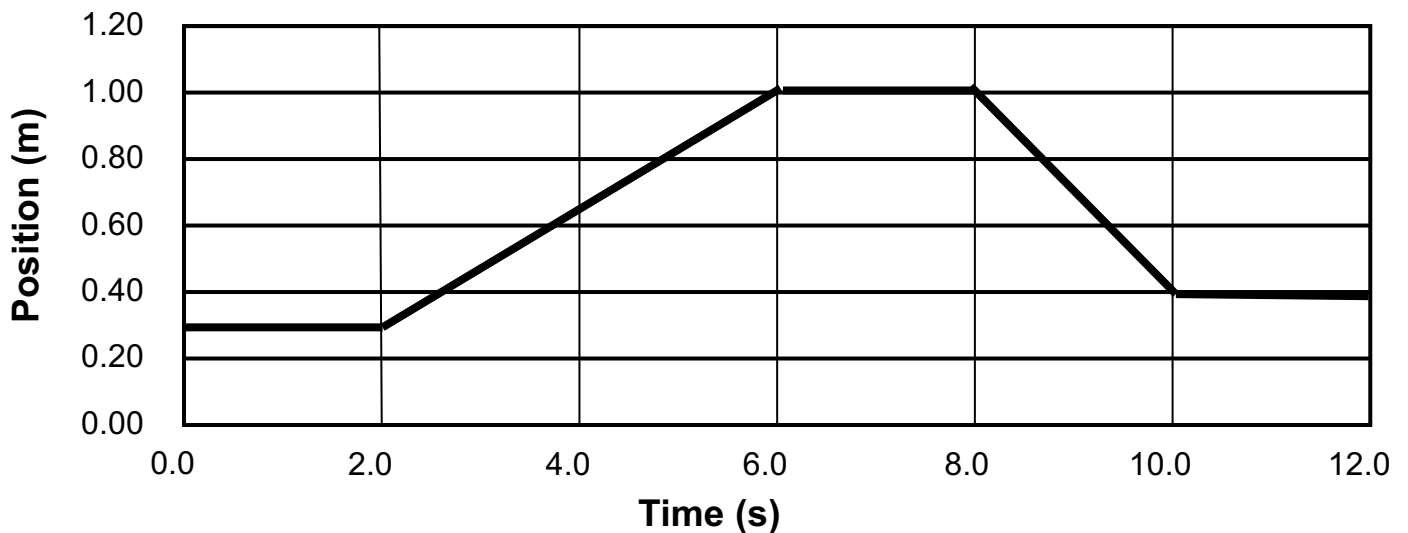
Beach ball



Lab 1: One Dimensional Motion

Purpose: During this laboratory you will investigate graphs of position and velocity and related concepts by using the computer to track the motion of an object you are holding. (Activities that involve studying your own motion are called “kinesthetic” activities and are believed to increase understanding and retention.) In the process of doing this lab you will also begin to gain familiarity with the computerized data acquisition which you will use many times throughout the semester.

Part 1: Position vs. Time



- 1) Graph Interpretation and Prediction of Motion: Carefully describe how you would have to move to produce the graph shown above. Be sure to keep in mind the position and the time. For example, “Hold still at 0.30 m for 2.0s.” “Move from 0.30 m to 1.00 m taking 4.0 s to do so,” *etc.*

2) Interpretation of the graph: Answer the following questions **showing your work with units.**

A. What is the average velocity during the first 2.0 seconds?

B. What is the average velocity during the first 6.0 seconds?

C. What is the instantaneous velocity at 4.0 seconds?

D. What is the instantaneous velocity at 7.0 seconds?

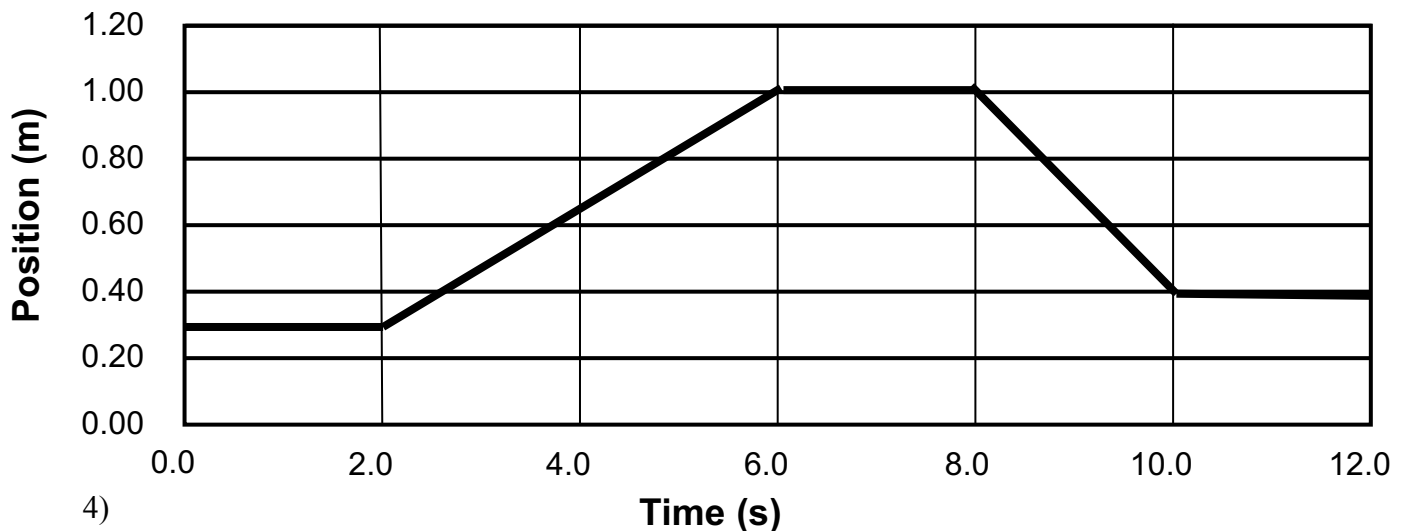
E. What is the instantaneous velocity at 9.0 seconds?

3) Match-a-Graph: In this activity you will track a piece of cardboard using a motion sensor. The computer will automatically make a graph of position vs. time of the cardboard as it is moved. The object is to move the cardboard so that you reproduce the graph above as accurately as you possibly can.

1. Turn on the computer if it is not already running.
2. Start the program 'Capstone.'
3. On the left side of screen under tools, click hardware setup.
4. Click digital input '1' and select "motion sensor II". You can click hardware setup again to minimize window.
5. Set the sampling rate at 40 Hz located at the bottom of your screen on the controls palate.
6. With the help of your instructor or lab assistant, set up the program so that it is ready to produce a graph of position vs. time. Take note of how to do this since you will do it other times during the semester:

- Drag the 'Graph'  button located on the right side of screen under Display Palate to your workspace.
- Select the measurement button on the graph to set the x and y (or better x and t) axis and minimum and maximum values to match the graph. You should also turn off the minor grid (this simply makes it print cleaner).
- To find a value at a particular point, use the coordinates button, , located at the top of the graph.
- To begin recording data, Click **Record**  in the Controls Palate at the bottom of the screen.
- Note: Deleted data are removed from the data set and the data cannot be restored at later time. You can immediately undo a delete action by clicking Undo

Try to reproduce the graph as accurately as you can. **You will probably need several attempts to get a satisfactory graph. Show your graph to the instructor.**



Graph Interpretation:

Now that you have a graph of your real motion that matches the given graph as closely as you can. Find the slope of your graph that corresponds to the 2.0s to 6.0 s region of the given graph.

- On toolbar click **Data Highlighter** , click and drag the area from 2.0s to 6.0s.
- Click the down arrow (▼) on **Curve Fit**  button located at the top of the graph and choose 'Linear Fit.' The area will be highlighted and the slope of that region will be displayed.

A. Slope (with units) is _____

What is the percent error between your slope and your answer to 2.C) above?

$$\%error = \frac{|Experimental - Theoretical|}{Theoretical}$$

B. % error = _____

C. Does this percent error make sense? Think about how accurate your measurements could be and how accurately a person could move. Explain your reasoning.

Use the computer to find the instantaneous velocity at 9.0s.

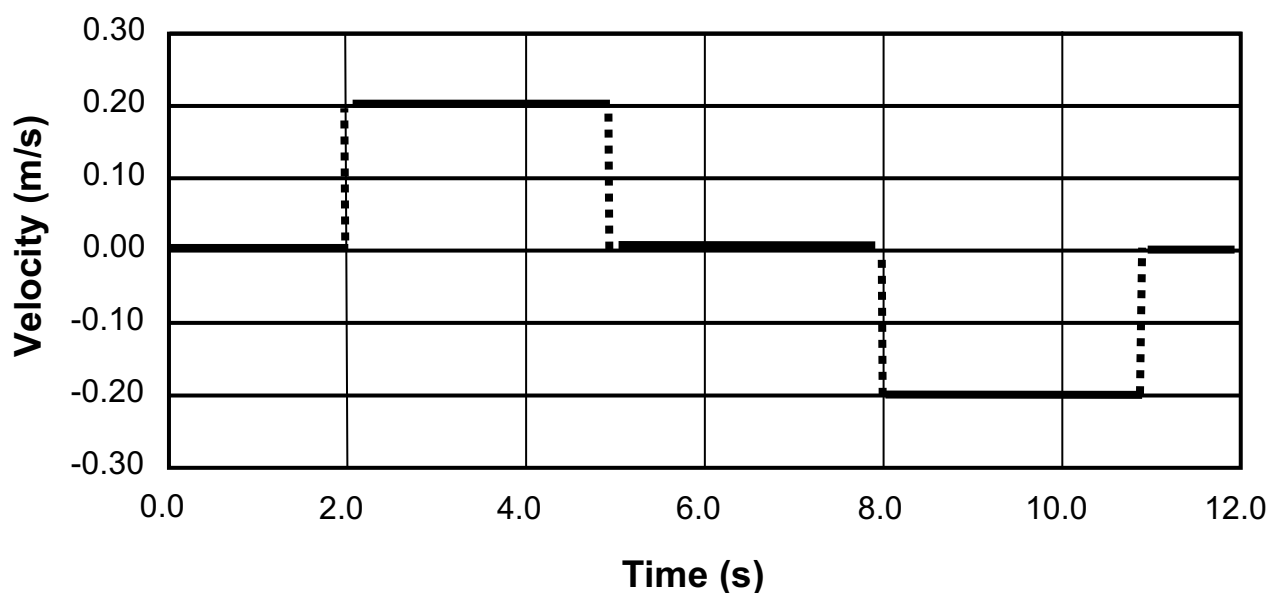
D. Instantaneous velocity (with units) _____

E. Instantaneous velocity calculated (part 2.E above) _____

F. % error between your measured and calculated instantaneous velocity at 9s

%error = _____

Part 2: Velocity vs. Time



- 1) Graph Interpretation and Prediction of Motion: Carefully describe how you would have to move to produce the graph shown above. Be careful, it is velocity vs. time. Assume an initial position of 0.30m.
- 2) Set the graph in Capstone to measure velocity vs. time (click on title of y-axis to change). Produce a graph that matches the graph above as closely as possible. Be sure each lab partner has an opportunity to try. When you have your best graph, **show it to your instructor**.

Part 3: 1 Dimensional Motion with Constant Acceleration

In the absence of air resistance or friction, the acceleration of any body near the surface of the earth is the acceleration due to gravity, $g = 9.8 \text{ m/s}^2$. You will measure the acceleration of two objects (i.e. basketball and small beach ball) by measuring the slope of a velocity versus time graph.

Move the motion sensor to the top of the rod and have it face downwards. You will drop each object 5 times and find the slope. Be sure to only measure the slope of the falling object (not once it hits and bounces up again). For each object, you will then find the average acceleration (average of the 5 measurements), the percent error between the known value and the average acceleration, and the standard deviation of the 5 measurements. You may use excel to find the standard deviation. If the 5 data points were in column A in cells 1-5, the command would be “=stdev(A1..A5).

	<i>Basketball</i>	<i>Beach ball</i>
<i>Trial 1</i>		
<i>Trial 2</i>		
<i>Trial 3</i>		
<i>Trial 4</i>		
<i>Trial 5</i>		
<i>Avg. Acceleration</i>		
<i>% Error</i>		
<i>Standard Deviation</i>		

In any measurement or experiment, there are measurement uncertainties or experimental errors. These are not mistakes, but inherent inability to make perfect measurements or unaccounted for parts of the experiment. Rounding is not a measurement uncertainty or experimental error, because using correct significant figures would account for that.

There are two main types of measurement uncertainties. Random uncertainties occur because no measurement is ever perfect. For instance, when measuring a length with a ruler, a person can only be accurate to about half a millimeter. For random uncertainties, sometimes the measurement is too large and sometimes it is too small, so taking a large number of trials and taking an average will reduce these. Systematic error or uncertainties occur because of a neglected assumption (i.e. neglecting to take friction into account) or as part of the experimental design (i.e. a non-level ramp could always make an object move faster than it should). Systematic uncertainties are usually present when all of the data fall below or all fall above the accepted values.

A percent error is one method of comparing an experimental value to a measured one, but what is a “good” percent error? That depends on the experiment and the measurement uncertainties. A standard deviation is one way of quantifying random uncertainties. If the accepted value falls within 1 standard deviation of the mean, then the uncertainties are probably random. If not, and especially if all the values are either above or below the accepted value, you should try to find systematic errors to explain the discrepancy.

1) For the basketball:

A. Does the accepted value of the acceleration due to gravity fall within one standard deviation of the mean?

B. Would the most important measurement uncertainty be random or systematic?

C. Explain one possible source of uncertainty. (It should be consistent with your answer to B)

2) For the beach ball:

A. Does the accepted value of the acceleration due to gravity fall within one standard deviation of the mean?

B. Would the most important measurement uncertainty be random or systematic?

C. Explain one possible source of uncertainty. (It should be consistent with your answer to B)