PURPOSE: To understand the how position-time and velocity-time graphs describe motion in the real world.

INTRODUCTION
In this lab you'll be performing four activities that will allow you to compare motion graphs with actual motions, and seeing how motion graphs can be used to visualize motion in the real world.
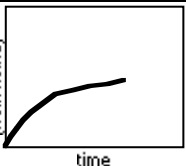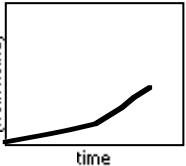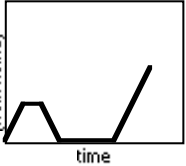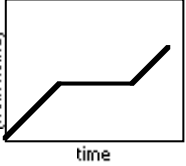
MATERIALS:
Sonic Ranger (motion detector), LabPro interface, LoggerPro software, low-friction cart, smart pulley and clamp, string, masses, computers
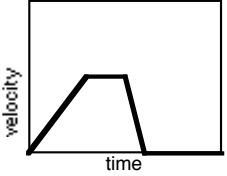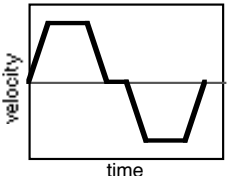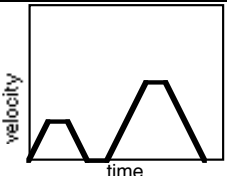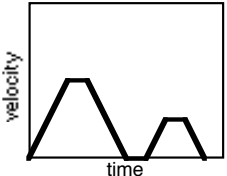
PROCEDURE:

Activity 1: Graphing Stories
  Part A. Identify which **position-time** graph, 1-4, is associated with each of the following "going to school" stories, *a-c*. For the graph that doesn't match a story, write your own story that matches the motion described by that graph.

Motion Graphs	Which story matches the graph?	Stories
1.	1. _____	a. I had just left home when I realized I had forgotten my books, so I went back to pick them up.
2.	2. _____	b. I was riding my bike just fine until I had a flat tire; I fixed it and then continued to school.
3.	3. _____	c. I started out slowly, but sped up when I realized I was going to be late for school.
4.	4. _____	d. [Write your own story here for the remaining graph.]

Part B. Identify which **velocity-time** graph, 1-4, is associated with each of the following "going to school" stories, *a-c*. For the graph that doesn't match a story, write your own story that matches the motion described by that graph.

Motion Graphs	Which story matches the graph?	Stories
1.	1. _____	a. While driving to school my car got a flat tire, so I stopped to fix it. When I was done fixing the tire, I had to drive faster to school to avoid being late.
2.	2. _____	b. I was driving to school when my car broke down, so I parked it and walked the rest of the way to school.
3.	3. _____	c. I wasn't feeling well, so I drove to school to drop off my homework, and then drove back home.
4.	4. _____	d. [Write your own story here for the remaining graph.]

Activity 2: Sonic Ranger–Graph Matching

1. Stand facing the sonic ranger that is attached to the work stand with a clamp. The sonic ranger is connected to the computer, which will graph your motion in real time.

2. Choose a graph from the list for *Activity 1: Graphing Stories*. Try to create the same graph by walking toward (or away from) the sonic ranger. A graph of your motion will appear on the screen.

3. Write below which graph (A1, A2, A3, A4, B1, B2, B3, or B4) you tried to match. Then sketch the graph displayed by the computer that indicates your best attempt at matching your graph. Remember to label the axes on your graph.

Matching Graph _____

Activity 3: Sonic Ranger–Graphing Motion

Stand facing the sonic ranger, which will graph your motion in real time. Note that there are two graphs that will be displayed–*position versus time*, and *velocity versus time*–as you move back and forth in front of the sonic ranger.

1. Stand near the sonic ranger and back away slowly at a constant speed, observing the graphs made. Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.
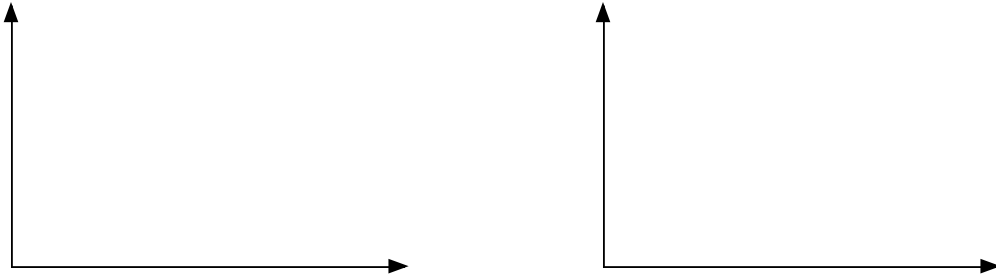
2. Stand near the sonic ranger and back away at a constant speed, but more quickly then you did in *Part 1* above. Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.
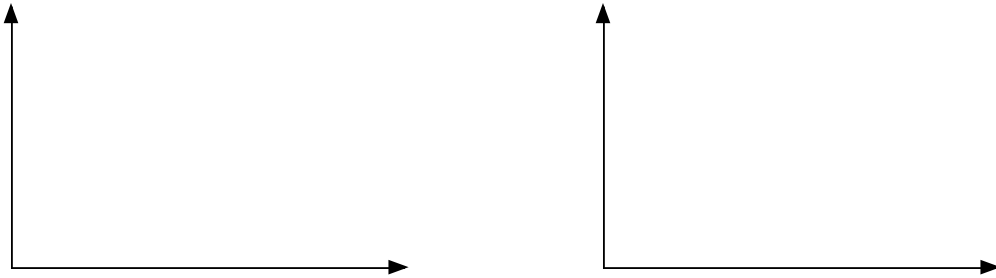
3. In which *position-time* graph above, *1* or *2*, is the slope of the graph steeper, and why?

4. Why should the *velocity-time* graphs in both parts *a* and *b* above be horizontal lines?

5. Now observe a new motion, beginning far away from the sonic ranger and approaching it slowly at a constant speed. Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.

6. Now begin your motion far away from the sonic ranger, and approach it more quickly then you did in *Step 5* above, observing the graphs made. Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.

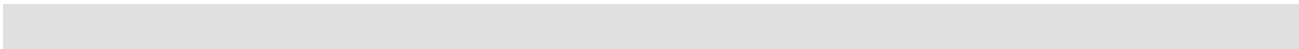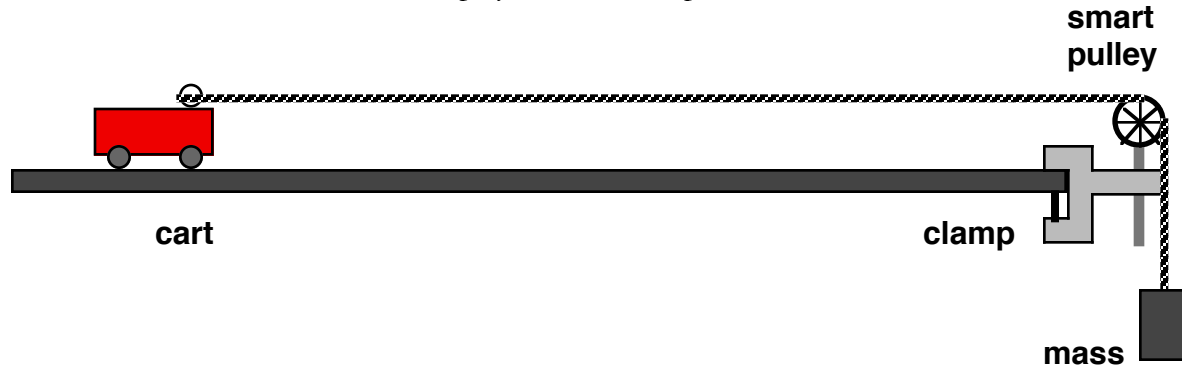7. In which *position-time* graph above, *5* or *6*, is the slope of the graph steeper, and why?

8. Why should the *velocity-time* graphs in both parts *5* and *6* above be horizontal lines?

Activity 4: Accelerated Motion
This station has a runway, a cart attached to a mass with a string, and a "smart pulley," which will record the motion of the car and display it on the computer.

1. Move the cart back on the table so that it when it is released, the smaller mass will pull the string, which will move the car across the table. Hold the car in this position for a moment.

2. A second student should place his/her hand in front of the smart pulley, to catch the accelerating cart and keep it from hitting the pulley.

3. A third student should activate the computer. As soon as the computer begins collecting data, the cart should be released.

4. Observe the *Position vs. Time* and *Velocity vs. Time* graphs that are produced on the monitor. Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.

5. Repeat the experiment, this time using the larger mass on the end of the string Make a sketch of the *position-time* and *velocity-time* graphs in the space below, being sure to label your axes.

6. In which set of graphs (#4 or #5) did the car accelerate more quickly? How can you tell that just from looking at the graphs?

7. Your cart should have accelerated constantly. Describe how the shape of both the *position vs. time* and *velocity vs. time* graphs each support this statement.

TEACHER NOTES:

There is a fair amount of pre-lab set-up for the teacher involved with this lab, and students will almost certainly need some help in managing the computer interfaces. One common software-hardware setup involves using LoggerPro software with LabPro interfaces connected to Motion Detectors, or a Smart Pulley for Activity 4.

Specific suggestions for the lab and each activity:

1. Set up separate stations for each activity.
2. Break students up into 4 groups, one for each activity. Set a time limit for rotating through each station, although flexibility is required–not all activities require the same amount of time.
3. Activity 1 requires no setup, and can be performed at students' desks.
   Activity 2 requires a sonic ranger/LabPro/computer setup and a free corridor of some 3-4 meters in which to operate.
   Activity 3 requires the same.
   Activity 4 requires a smart pulley clamped to the edge of a table, two different masses, and a dynamics cart attached to a string as per the diagram in this lab.
4. Remind students to label each graph clearly with units. EXAMPLE: Position (m) or Velocity (m/s), but numbers are not necessary.
5. Ensure the GRAPH setting for each of the two sonic ranger stations is set up thus:
   time of experiment = 5s
   distance = 4 m
   velocity range = -4 - +4 m/s
   Manual graphing (i.e. NOT autoscale of any kind). Autoscaling for varying data will change the axes and eliminate the possibility of seeing varying slopes for varying speeds.
6. Ensure the GRAPH setting for the smart pulley station is set up as follows:
   time of experiment = 1 s
   distance = 1 m
   velocity range = 0 – 4 m/s
   Manual graphing (i.e. NOT autoscale of any kind)
7. After creating the settings for each station, consider saving as an experiment file, which can be reloaded each time you wish quickly set up the lab for a new class.