PHY 120 Lab 1: Kinematic Graphs I[1]

Name ______________________ Date ____________

A. Position vs. Time Graphs of Your Motion

What does a position vs. time graph look like when you move slowly? When you move quickly? What happens when you move in different directions?

In the following activity, use the motion sensor with PASCO Capstone software to record your own motion as you walk towards and/or away from the sensor.

Making Position vs. Time Graphs

Launch the PASCO Capstone software and open experiment kin_1. (Ask your instructor where to find the files for the Kinematics Lab.)

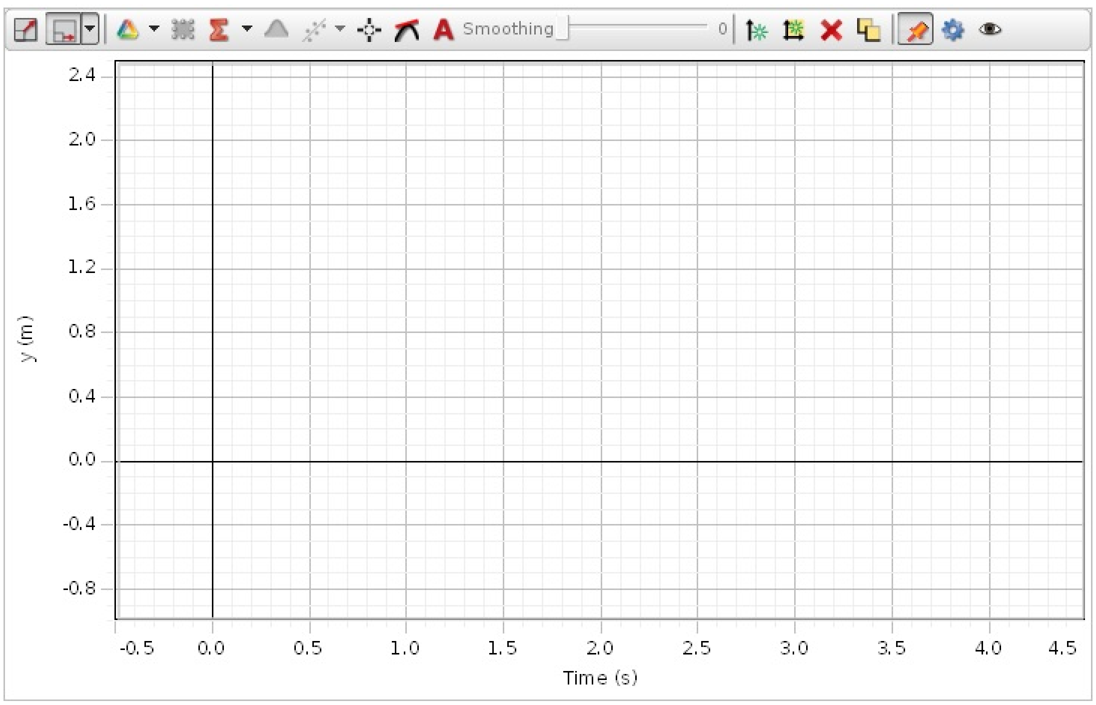
1. Make a position vs. time graph for different walking speeds and directions. As you perform each kind of motion, sketch the resulting position vs. time graph on the axes provided below. Your final graph should have three lines.

a. Start at x = -0.5 m and walk slowly and steadily in the positive direction.

b. Start at x = -0.5 m and walk somewhat faster in the positive direction.

c. Start at x = +2.0 m and walk slowly and steadily in the negative direction.

Label the three lines a, b, and c.

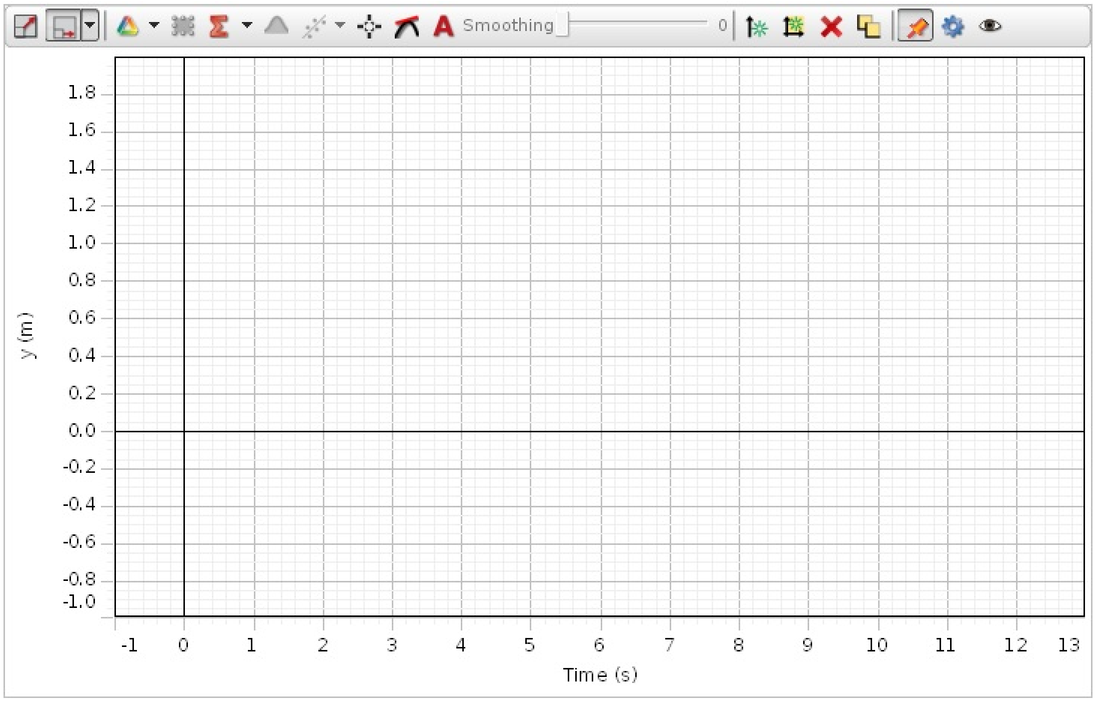


Open experiment kin_2.

2. **Predict** the shape of the position vs. time graph that results when a person starts at the origin, walks in the positive direction slowly and steadily for 4 seconds, stops for 4 seconds, and then walks in the negative direction more quickly. **Sketch your prediction** on the axis provided below using a *dashed line*.

Test your prediction by generating a graph for the motion described above. Sketch your observation on the same graph as your prediction using a *solid line*.

[1] 1993-94 P. Laws, D. Sokoloff, R. Thornton. Supported by the National Science Foundation and U.S. Department of Education (FIPSE). These materials have been modified for use at Union College.



Matching a Position Graph

Open experiment kin_3.

By now you should be pretty good at predicting the shape of a graph of your movements. Can you do this the other way around by reading a position vs. time graph and figuring out how to move to reproduce it?

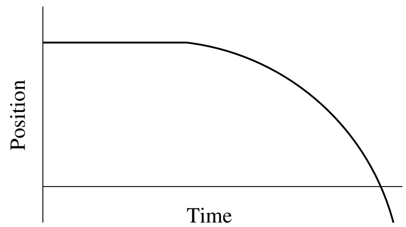
3. Try to move so as to match the graph you see on the computer screen. You may try a number of times. It helps to work as a team. Get the times right. Get the positions right.

In the space below, describe the motion required to reproduce the given position vs. time graph.

Other Position vs. Time Graphs

Open experiment kin_4.

4. Can you make a curved position-time graph? Try to move so as to produce something similar to the graph shown below.



a. Describe how you must move to produce a position vs. time graph with the shape shown.

b. What is the main difference between motions which result in a straight line position vs. time graph and those that result in a curved line graph.

B. Velocity vs. Time Graphs

Another way to represent your motion during an interval of time is with a velocity vs. time graph. Remember that velocity can be positive or negative. You will probably find that velocity vs. time graphs are more challenging to create and interpret than position vs. time graphs.

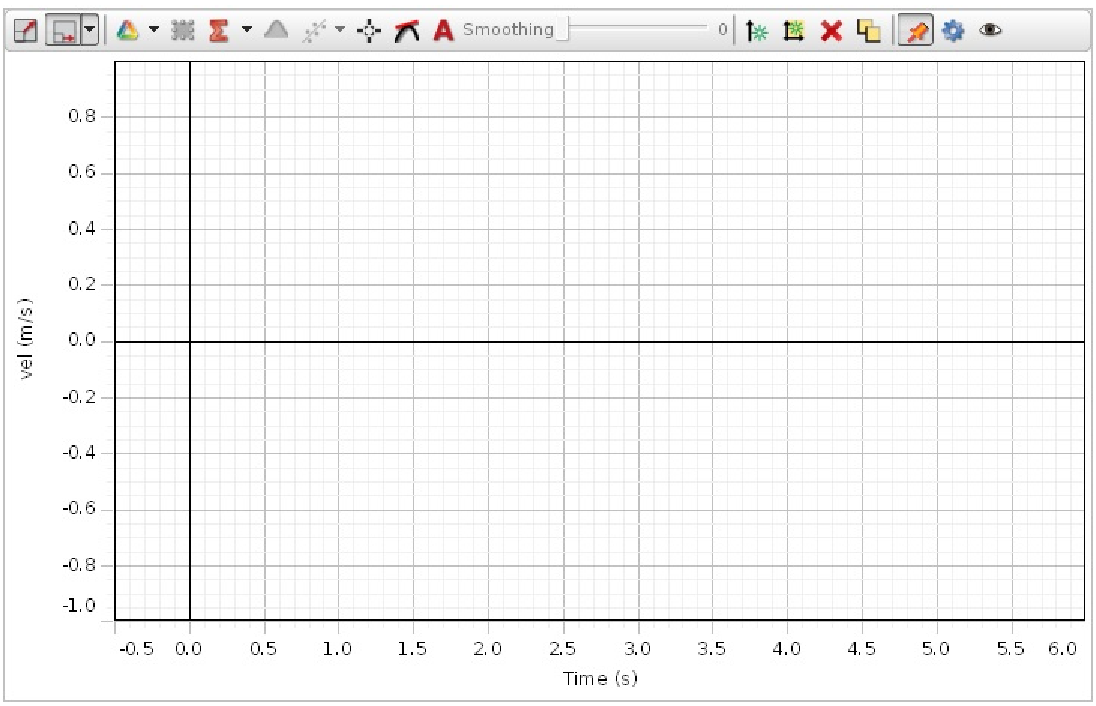
Making Velocity Graphs

Open experiment Activity kin_5.

5. Make graphs of your velocity for different walking speeds and directions.

a. Make a velocity graph by walking quite slowly and steadily in the positive direction. Try again until you get a graph you are satisfied with. Sketch your graph on the axes below and label it a.

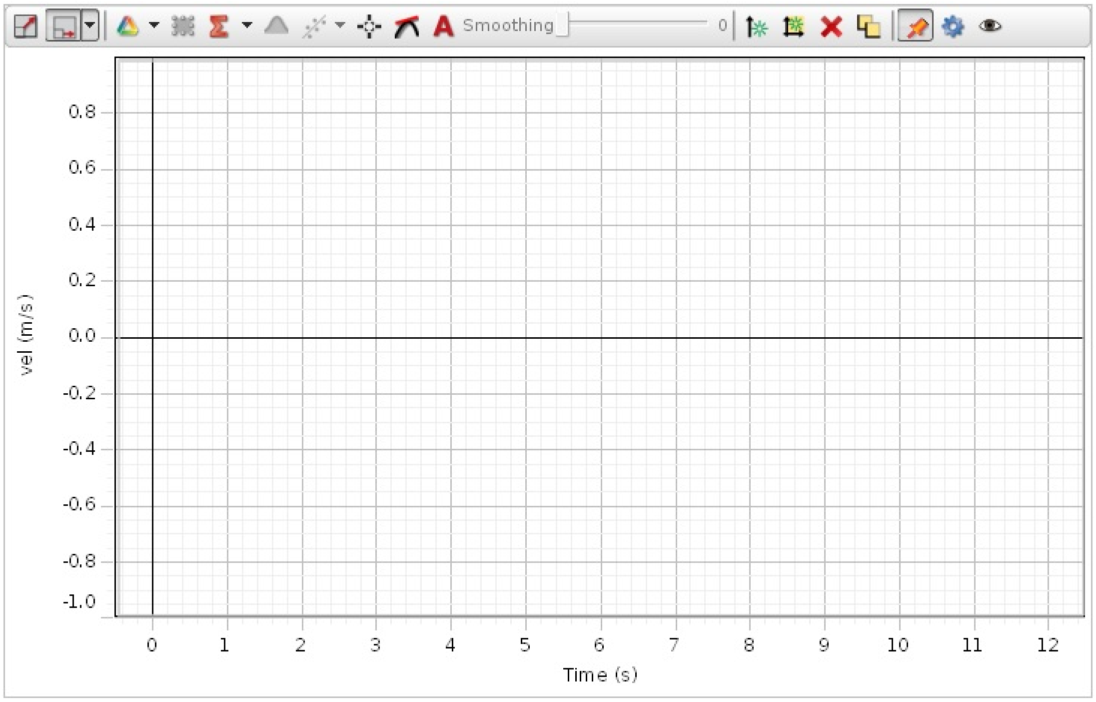
b. On the same axes, make a velocity graph by walking in the positive direction somewhat faster. Label this line b.



Open experiment kin_6.

6. Using a *dashed line* on the axes provided, sketch the velocity graph that you would predict for: walking away from the detector slowly and steadily for 4 seconds, then standing still for 4 seconds, then walking toward the detector steadily somewhat faster than before.

Test your prediction by moving in the way described and making a graph of the motion. Try again until you think your motion matches the description. Be sure the 4-second stop shows clearly. Sketch your observation on the graph with your prediction using a *solid line*.



C. Relating Position and Velocity Graphs

Since position vs. time and velocity vs. time graphs are different ways to represent the same motion, you should be able to figure out the velocity at which an object is moving by examining its position vs. time graph. Conversely, you should be able to figure out by how much an object's position has changed (the displacement) from a velocity vs. time graph.

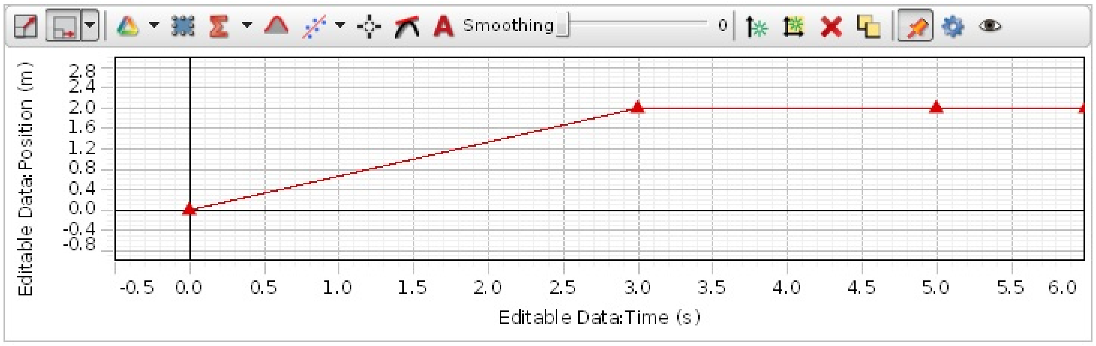
Predicting Velocity Graphs from Position Graphs

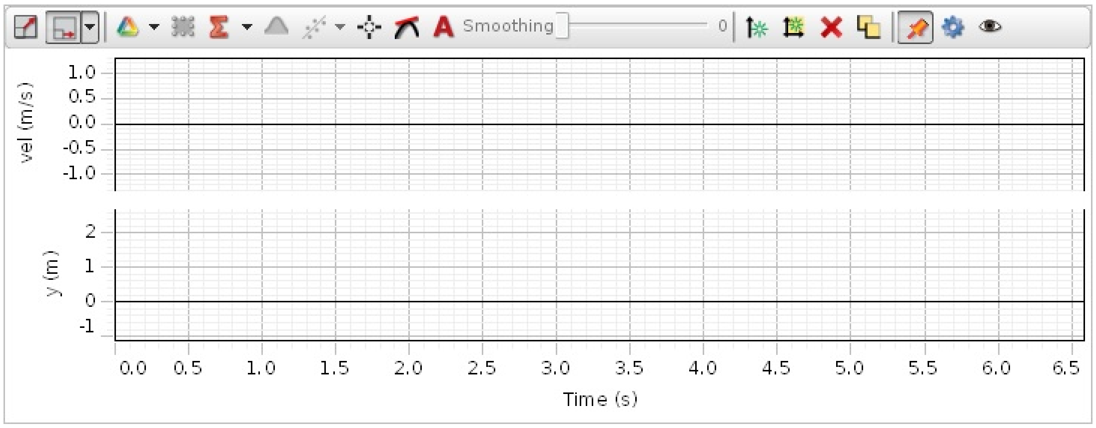
Open experiment kin_7.

7. Carefully study the position vs. time graph shown on the computer screen.

a. Predict the velocity vs. time graph that would result from that motion. Sketch it on the velocity axes below using a *dashed line*.

Then try to move so as to match the position vs. time graph. Walk as smoothly as possible. Sketch your observations on the position and velocity graphs using *solid lines*.





b. How would the position graph be different if you moved faster? Slower?

c. How would the velocity graph be different if you moved faster? Slower?

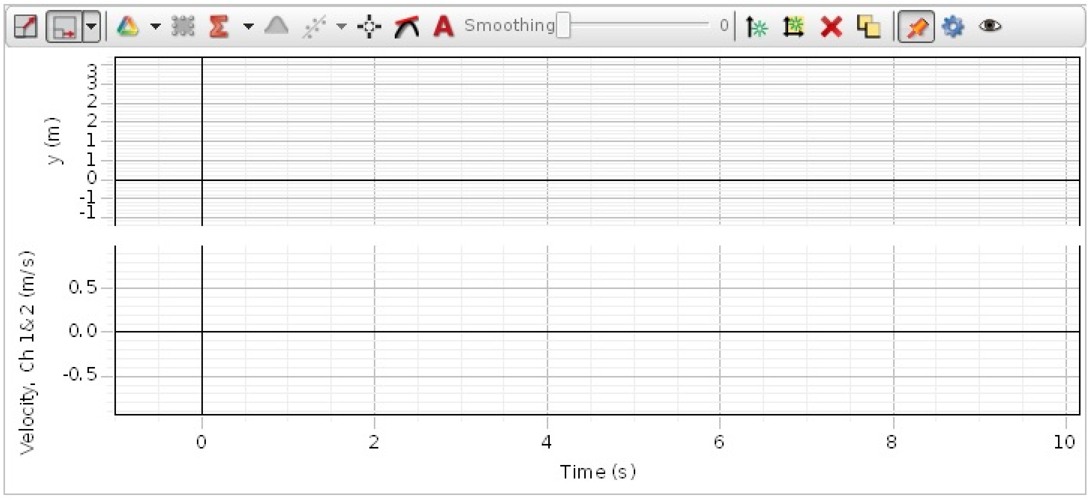
Predicting Position Graphs from Velocity Graphs

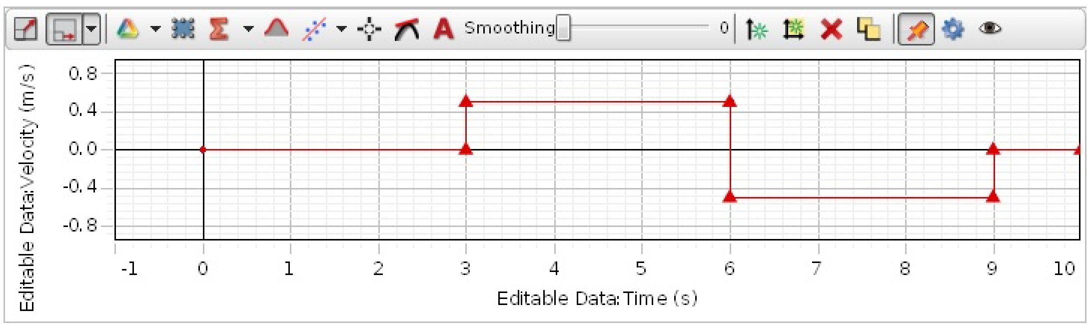
Open experiment kin_8.

8. Carefully study the velocity graph shown on the computer screen.

a. Using a *dashed line*, sketch your prediction for the corresponding position graph, on the axes provided. (Assume that you started at the origin.)

Now do your best to duplicate the velocity vs. time graph by walking. When you have a good match of the velocity graph, sketch your observations on the position and velocity graphs using *solid lines*.





b. How can you tell from a velocity vs. time graph that the moving object has changed direction?

c. How can you tell from a position vs. time graph that your motion is steady (motion at constant velocity)?

d. How can you tell from a velocity vs. time graph that your motion is steady (constant velocity)?

PHY 120 Lab 1: Kinematic Graphs II[1]

Name ______________________ Section__________ Date __________

Velocity and Acceleration Graphs

When the velocity of an object is changing, it is important to know how fast the change is occurring. The rate of change of velocity is known as acceleration. In this part of the lab you will create and interpret velocity vs. time and acceleration vs. time graphs for some relatively simple motions. In the following activities you will use a fan-cart on a track to produce motion in which velocity is changing at a constant rate. Mount the motion sensor on the track at the x = 0 end.

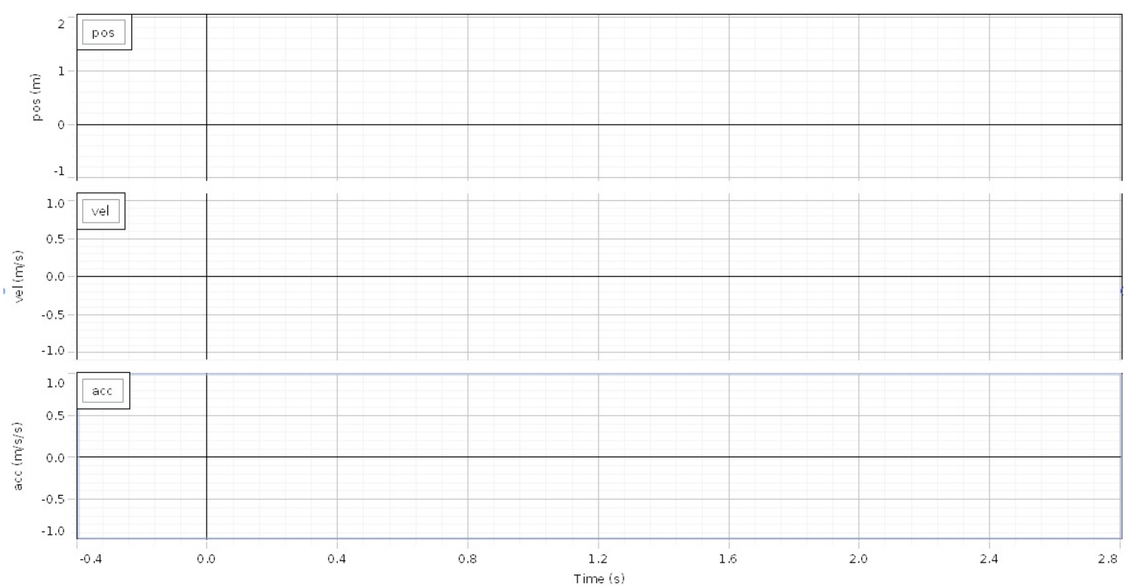
Speeding Up

Open Capstone experiment kin_9.

1. Set the fan cart on the track near the x = 0 end of the track, with its fan end toward the motion sensor so that it will speed up in the positive x-direction. Turn on the fan to low power. Release the cart from rest. Try doing this a couple of times without recording the motion with the computer. Turn off the fan unit when not observing the motion to save the batteries.

a. Predict the position vs. time, velocity vs. time, and acceleration vs. time graphs for the motion of the fan cart. Using *dashed lines*, sketch your predictions on the axes provided below.

Test your predictions by recording the motion with the motion sensor. Start recording data just after the cart is released. Turn off the fan unit when not recording motion to save the batteries. Repeat, if necessary, until you get nice graphs. Using *solid lines*, sketch the observed graphs on the same axes as your predictions.



b. How does your position vs. time graph differ from the position vs. time graphs for constant velocity motion that you observed earlier?

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c. What feature of your velocity vs. time graph indicates that the cart was speeding up?

d. According to the acceleration vs. time graph, during the time that the cart is speeding up, is the acceleration positive or negative? Explain how you know.

e. According to the velocity graph, how does the velocity vary in time as the cart speeds up? Does it increase at a steady rate or in some other way? Is the graph linear? Is the velocity proportional to time?

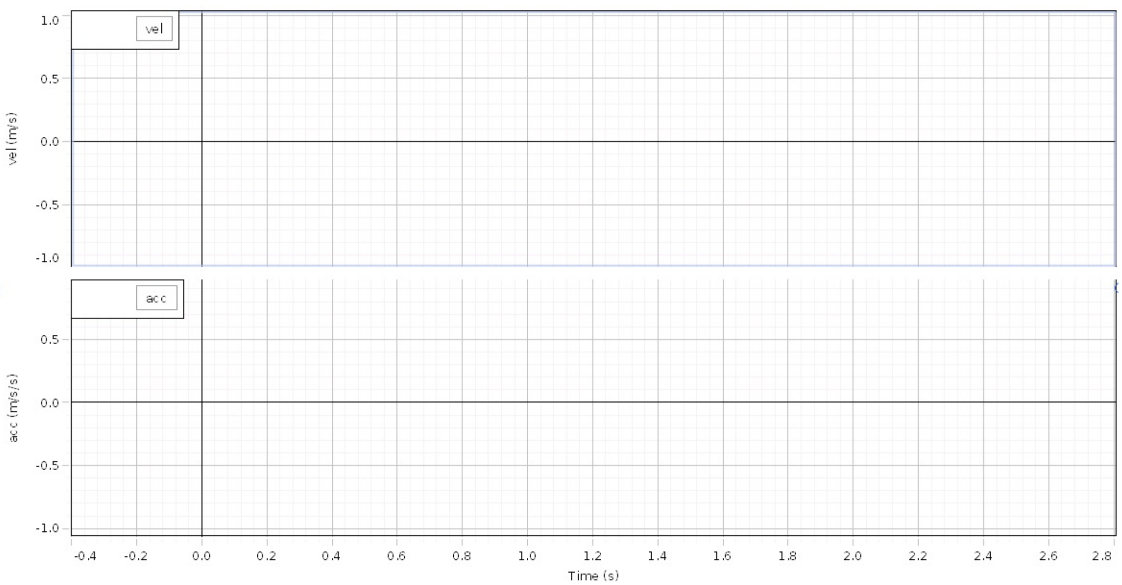
f. How does the acceleration vary in time as the cart speeds up? Is this what you expect based on the velocity graph? Explain.

Slowing Down in the Positive Direction

Open experiment kin_10.

2. Suppose you reverse the direction of the fan cart. Now if you start near the x = 0 end of the ramp and give the cart a push in the positive direction, it will travel in the positive direction while slowing down. Try doing this a couple of times without recording the motion with the sensor. Be sure to stop the cart (carefully) before it changes direction.

a. Predict the velocity vs. time and acceleration vs. time graphs for this motion. Sketch your predictions on the axes below using *dashed lines*. Under these circumstances do you expect the acceleration to be positive or negative (after it is released)? Circle your prediction: positive or negative.



Test your prediction by recording the motion with the motion detector. Place the cart near the x = 0 end of the track and set the fan on low. Give the cart a gentle push so that it coasts over most of the length of the track and start recording data just after the push. Have a partner stop the cart before it changes direction. (Be sure that your hand is not between the cart and the sensor, and that your fingers don't touch the fan.) You may have to try a few times to get a good run. Plot your observations with *solid lines* on the axis.

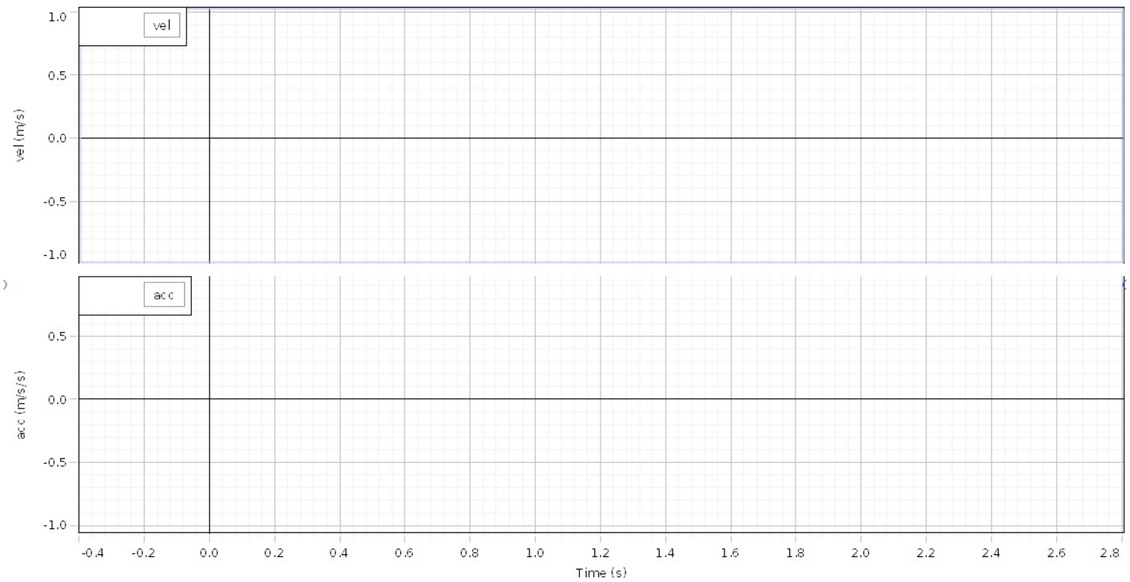
b. How can you tell the sign of the acceleration from a velocity vs. time graph?

c. How can you tell the sign of the acceleration from an acceleration vs. time graph?

Slowing Down in the Negative Direction

3. Consider the situation in which the fan cart is moving in the negative direction and slowing down.

a. Sketch your predictions for the velocity vs. time and acceleration vs. time graphs on the axes provided using *dashed lines*. Predict the sign of the acceleration in this case. Test your predictions and sketch the observed graphs on the same axes using *solid lines*.



b. Calculate the acceleration from two points on the velocity graph. Show your work below.

c. How does your calculated value for the acceleration agree with the measured value? The best way to make this comparison is to calculate the % difference given by

$$\% difference = \frac{measured\, value - calculated\, value}{calculated\, value} \times 100\%.$$

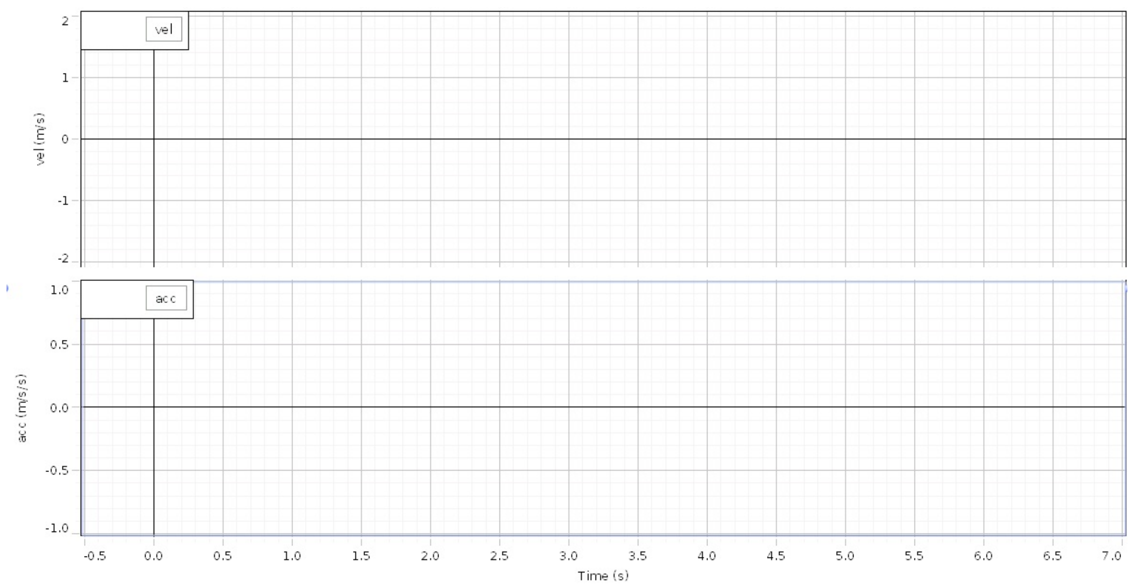
Reversing Direction

What happens when the cart slows down, reverses its direction and then speeds up in the opposite direction. How is its velocity changing? What is its acceleration? The setup should be as before. The fan will be set to low speed.

Open experiment kin_12.

4. Suppose you place the cart near x = 0, with the fan directed so that the cart will slow down and reverse direction after being given a push in the positive direction. Try it first without using the computer.

a. Sketch your predictions for the velocity and acceleration graphs on the axes provided using *dashed lines*. Your sketch should represent the motion beginning just after you release the cart and ending just before you catch the returning cart.



Test your prediction. Give the cart a push just after you turn on the motion detector. Try to have the cart cover most of the length of the ramp. (Be sure that your hand is not between the cart and the detector.) Sketch the observed graphs on the same axes using *solid lines*.

b. For each part of the motion–slowing down, at the turning point, and speeding up, indicate below whether the velocity is positive, zero, or negative by circling the appropriate sign in the table. Also indicate whether the acceleration is positive, zero, or negative.

	Slowing Down			Turning Point			Speeding Up		
Velocity	+	0	-	+	0	-	+	0	-
Acceleration	+	0	-	+	0	-	+	0	-

c. On the graphs of the observed motion, label the following times with letters:

A - When you started pushing the cart.

B - When you stopped pushing the cart.

C - When the cart reached its farthest point along the track.

D - When the cart had zero velocity.

d. According to your acceleration graph, what is the acceleration of the cart at the instant it reaches its farthest point along the track? What is its velocity at this point?