

One-Dimensional Motion

In this lab, we will analyze the motion of an object moving in one dimension.

Goals:

1. To acquire an intuitive understanding of displacement, speed, velocity, and acceleration in one dimension.
2. To recognize the patterns of position vs. time, velocity vs. time, and acceleration vs. time for the motion of objects with constant velocity or acceleration.

Overview:

You will begin your studies of motion using an ultrasonic motion detector attached to a microcomputer, to study the motion of your own body as well as that of a cart that increases and decreases its velocity at a steady rate. The rules for calculating velocity and acceleration from distance and time measurements are programmed into the motion software, so you can get a feel for what velocity and acceleration mean and how they are represented graphically.

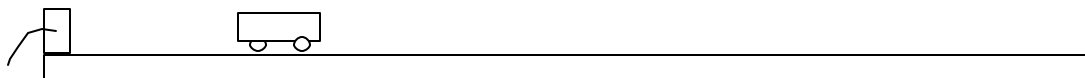
The ultrasonic motion detector sends out a series of sound pulses that are too high frequency for you to hear. These pulses reflect from objects in the vicinity of the motion detector and some of the sound returns to the detector. The computer is able to record the time it takes for reflected sound waves to return to the detector and then, by knowing the speed of sound in air, figure out how far away the reflecting object is. There are several things to watch out for when using a motion detector:

Pre-Lab:

Prior to coming to lab, read through this write-up and perform all the exercises labeled “**Pre-Lab**”. You will also want to copy this work onto the back pages of the lab, which I will collect at the beginning of lab.

PART I: Position vs. time

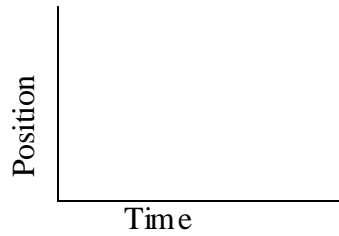
Make sure a LabPro interface box is connected to your computer, and has a motion detector plugged into the port labeled Sonic 2. Open “**Distance**” (in Physics Experiments/Physics 220-221/One-Dimensional Motion). Place the motion detector at the end of a level ramp as shown below. Switch the detector to its narrower sensor range (switch on top of detector). Place a cart on the ramp. Be sure the detector can “see” the cart.



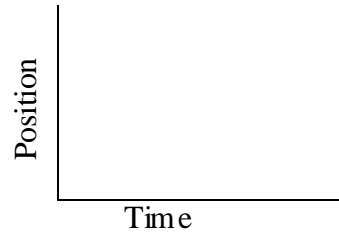
Make position-vs.-time graphs for different speeds and directions by clicking on the “Collect” button at the bottom of the screen and moving the cart in front of the motion detector at distances that are no closer than 0.05 m.

1. **Pre-Lab** Before carrying out the experiment, with a dashed line, sketch the graph you expect to see in each case:
2. During lab, try the following motions and, with a solid line, sketch the graph you observe in each case:

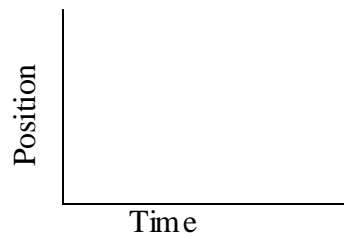
(a) Move the cart away from the detector slowly and steadily.



(b) Move the cart away from the detector moderately quickly.



(c) Starting at the other end of the ramp, move the cart toward the detector slowly and steadily.



3. **Pre-Lab:** What do you expect to be the difference between the graph you'll make by moving the cart away slowly and the one made by moving the cart away more quickly?

4. Were you correct? If not, what was the difference between the two graphs?

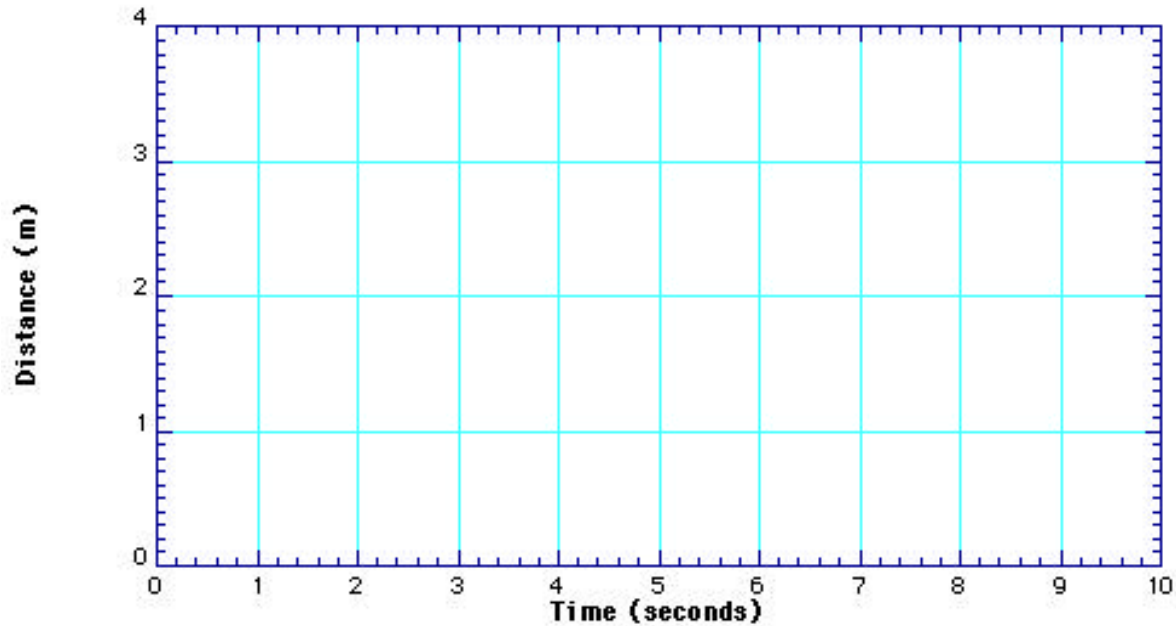
5. **Pre-Lab:** What do you expect to be the difference between the graph made by moving the cart toward and the one made moving the cart away from the motion detector?

6. Were you correct? If not, what was the difference between the two graphs?

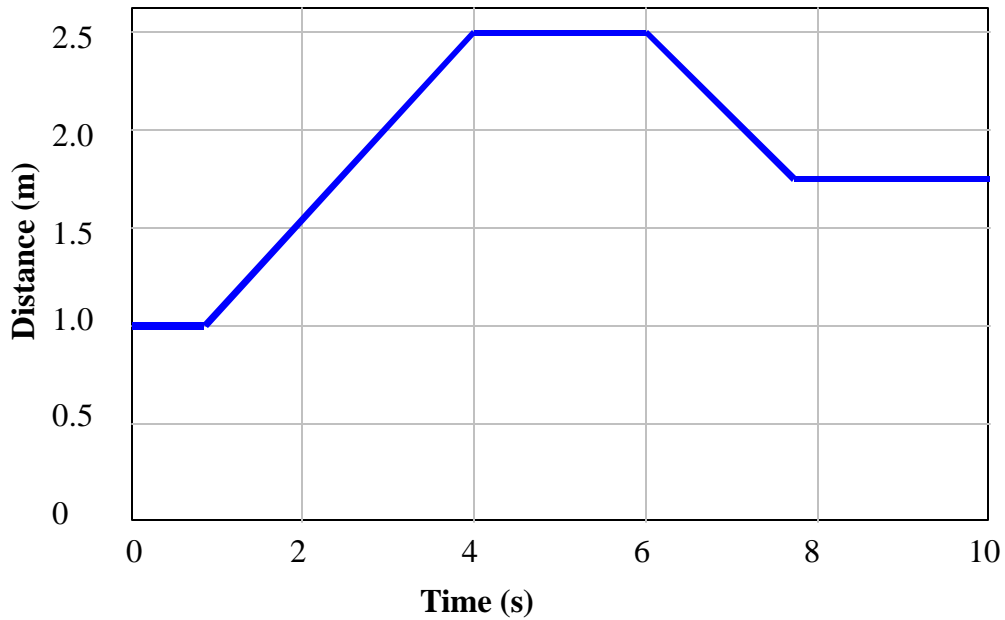
A good way to double check that you understand how to interpret position-vs.-time graphs is to predict the shape of a graph that would result for a motion described in words and then

carry out the motion. Suppose you were to start the cart 10 cm in front of the detector and move it away slowly and steadily for 4 seconds, stop for 4 seconds, and then move it toward the detector quickly

7. **Pre-Lab:** Sketch your prediction with a dashed line.
8. After making your prediction, click on the “Collect” button and move in the way described above. Sketch the actual graph of your actual motion with a solid line. You may change the numbers on the axes if you wish.



9. Is your prediction the same as the final result? If not, describe how you would move to make a graph that looks like your prediction.



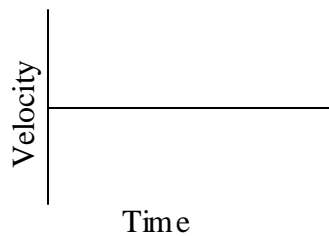
10. Describe in your own words how you would move in order to match this graph:

PART II: Velocity vs. Time

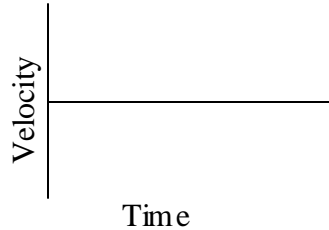
Now you will make some velocity-vs.-time graphs of the cart's motion. Pull down the *Data* menu and select *Clear All Data*, then click on the axis label "Distance" and when the Y-Axis Selection box comes up, de-select "distance" and select "velocity".

11. **Pre-Lab** Before carrying out the experiment, with a dashed line, sketch the graph you expect to see in each case:
12. During lab, try the following motions, and, with a solid line, sketch the graph you observe in each case:

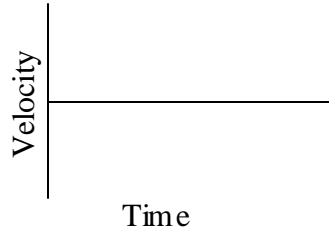
(a) Move the cart away from the detector slowly and steadily.



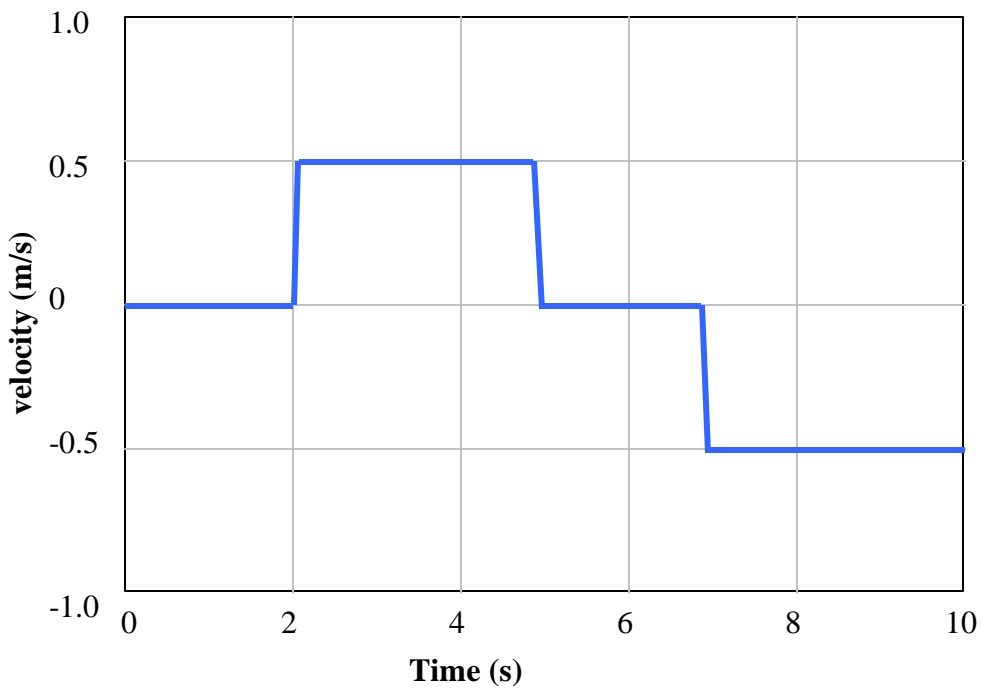
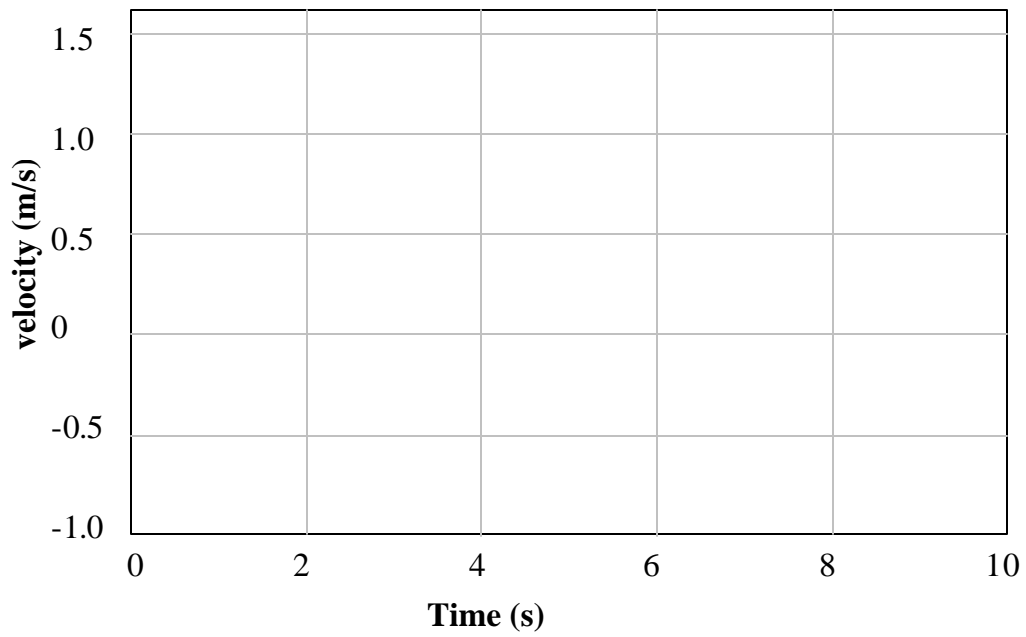
(b) Move the cart away from the detector moderately quickly.



(c) Starting at the other end of the ramp, move the cart toward the detector slowly and steadily.



13. **Pre-Lab:** What do you expect to be the most important difference between the graph made by *slowly* moving away from the detector and the one made by moving away *more quickly*?
14. Were you correct? If not, what was the most important difference?
15. **Pre-Lab:** How should the velocity- vs.-time graphs be different for motion *away* and motion *toward* the detector?
16. Were you correct: If not, what was the difference?
17. **Pre-Lab:** Suppose you were to undergo the following sequence of motions: move the cart away from the detector slowly and steadily for 4 seconds; keep it still for 4 seconds; move it toward the detector steadily about twice as fast as before. Sketch your prediction of the velocity- vs.-time graph on the axes below using a dashed line.
18. After making your prediction, repeat the motion until you are confident that it matches the description in words. Draw the actual graph on the axes above using a solid line.
19. Is your prediction the same as the final result? If not, describe how you would move to make a graph that looks like your prediction.



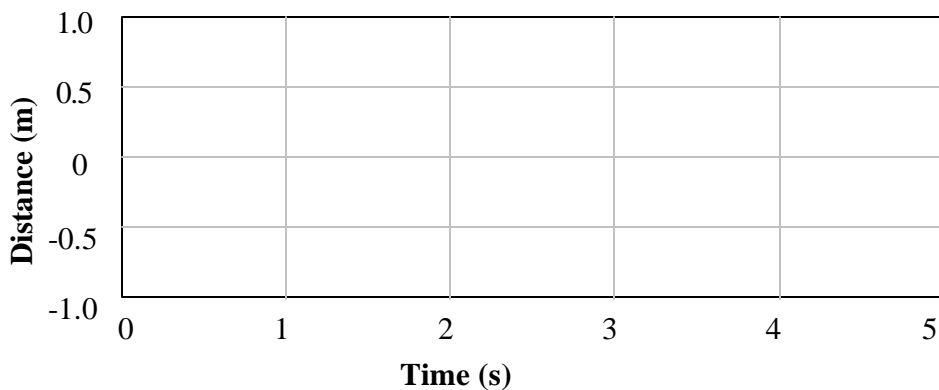
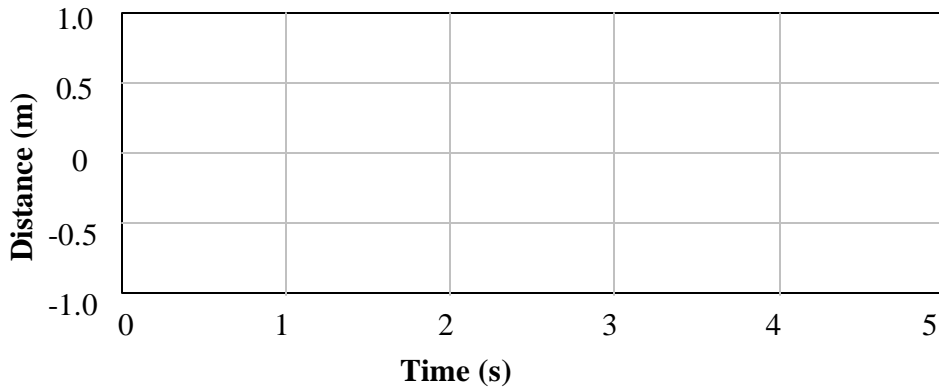
20. **Pre-Lab:** Describe in your own words how you would move the cart in order to match this velocity graph.

21. Is it possible for an object to move so that it produces an absolutely vertical line on a velocity-vs.-time graph? Explain.

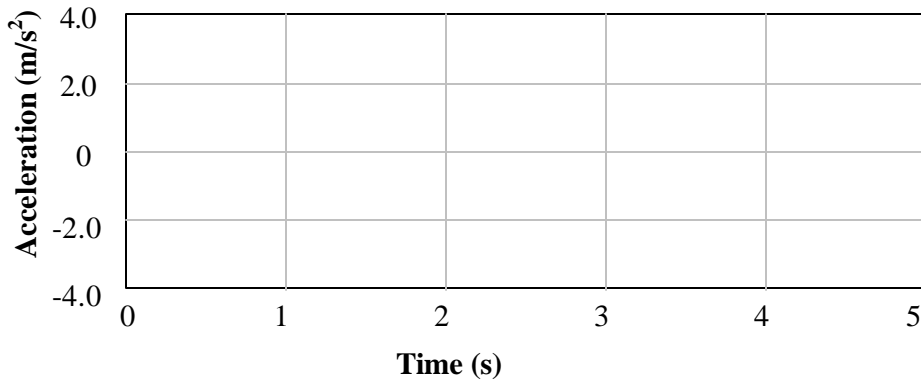
PART III: Acceleration vs. time

Now you will see how acceleration graphs are related to position and velocity graphs. You'll want two graphs like those shown below, to set them up, perform the following: a) Remove "Match" and "Velocity" from the Y-axis label and replace them with "Distance" (click on the Y axis label for the dialogue box), b) Clear All Data (under the **Data** menu), c) create an additional graph for displaying Velocity vs. Time (under the **Window** menu, select "New Wide Window" / "Graph"), d) for the new graph window, choose to display "Velocity" on the Y-axis, e) Change the maximum time to 5 sec on the two plots (click on the "10" on the time axis and type "5").

22. Put a cart on the track, give it a push, and click on the "Collect" button after your hand is out of the way. Record the resulting graphs below.

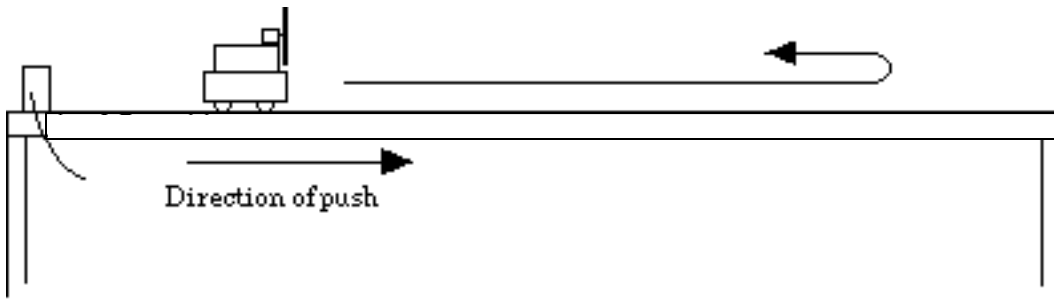


23. Sketch your prediction of the cart's acceleration (for the motion you just observed) on the graph below using a dashed line.



24. After making your prediction, display the acceleration graph of the cart by switching either the “Distance” or “Velocity” axis label to “Acceleration”; you may need to scroll down in the Y Axis Selection box to select “Acceleration”. Sketch it on the axes above using a solid line.

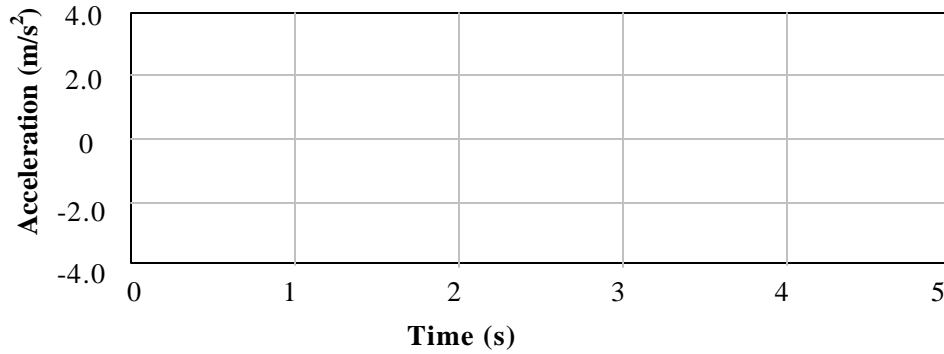
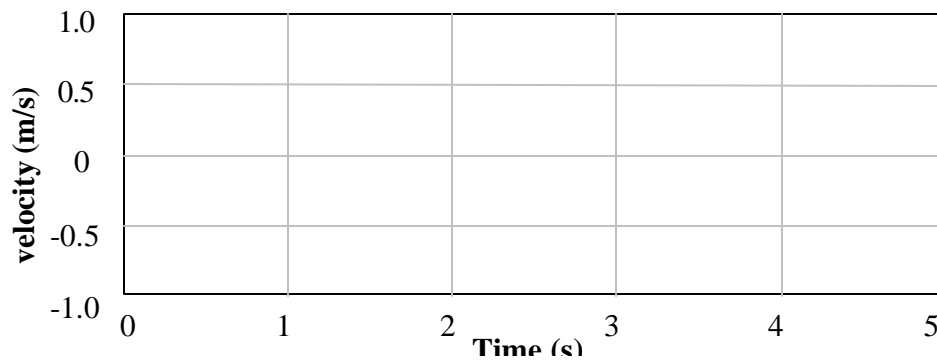
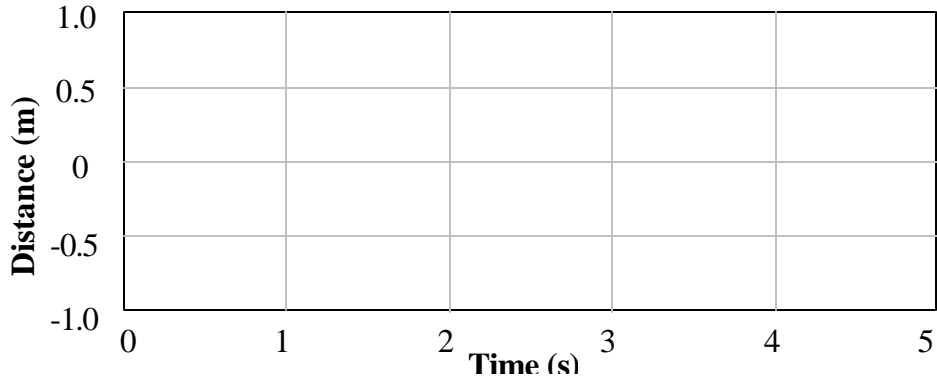
Set the second graph to display the velocity. Set the fan-powered cart to “low” and turn the cart around so that it would be blown toward the detector if released. Practice giving the cart a push *away* from the motion detector. It should move toward the end of the ramp, slows down, reverses direction and then moves back toward the detector. **Always catch the cart before it crashes at the end!**



25. **Pre-Lab:** For each part of the motion after you release the cart—*away from the detector, at the turning point, and toward the detector*—predict in the table that follows whether the velocity and acceleration will be positive, zero or negative.

	Moving Away	Turning Around	Moving Toward
Velocity			
Acceleration			

26. Collect data for this motion and sketch the graphs. **Label** the times: “A” - where the push ended (where your hand left the cart), “B” - where the cart reversed direction, and “C” - where you stopped the cart.

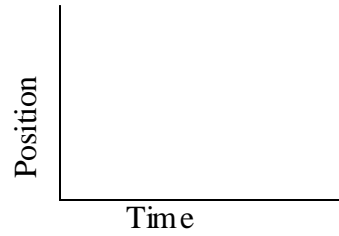


27. Put an “X” through any of your predictions in step 13 that were wrong and correct them.

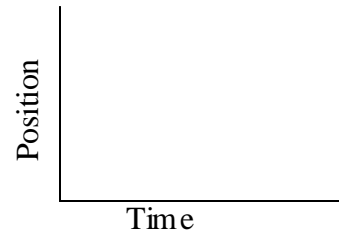
Pre-Lab #1

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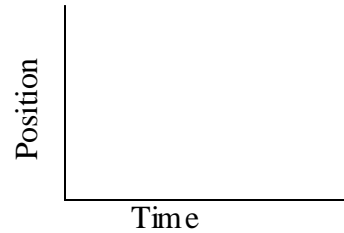
(a) Move the cart away from the detector slowly and steadily.



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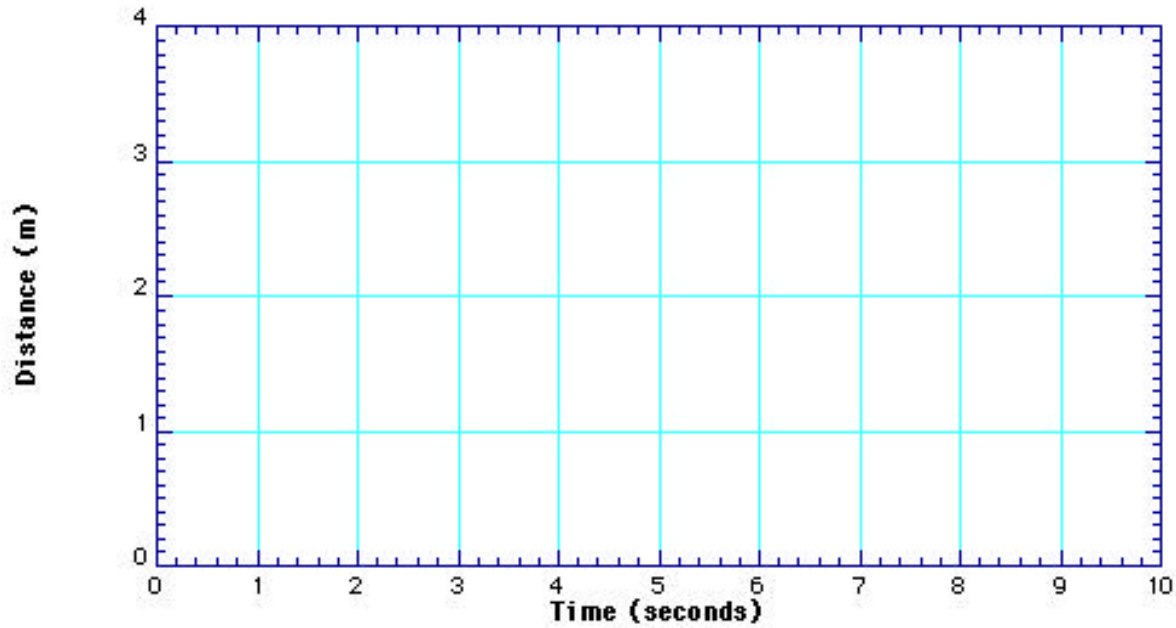
(c) Starting at the other end of the ramp, move the cart toward the detector slowly and steadily.



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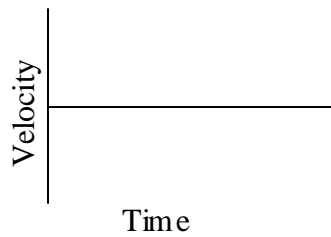
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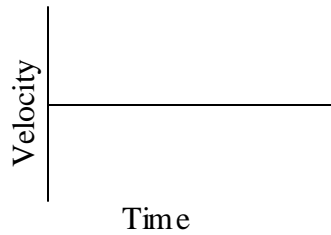


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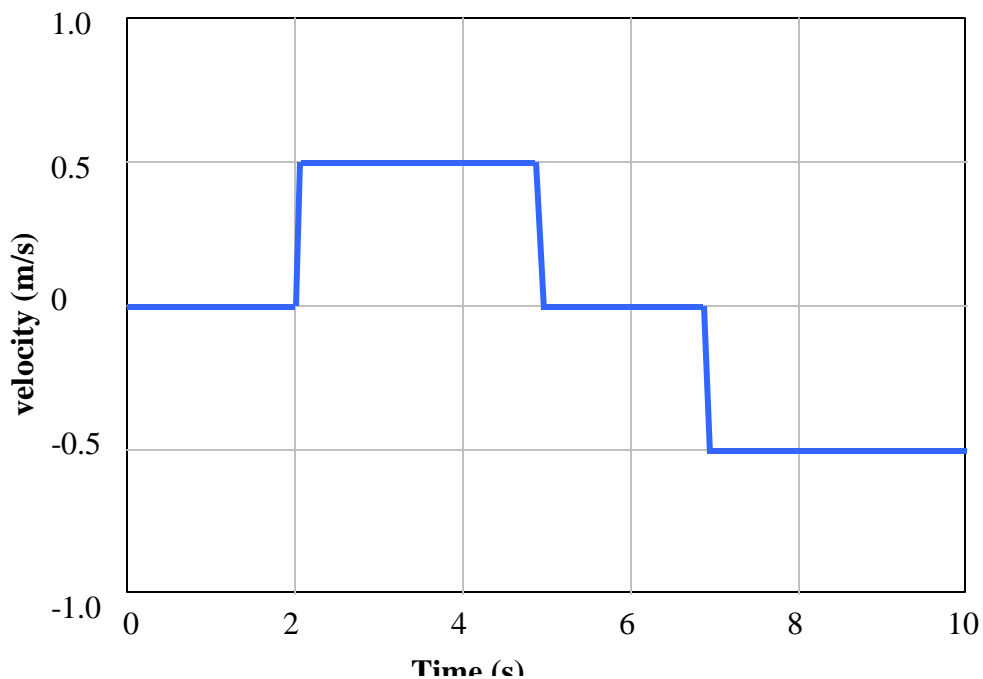
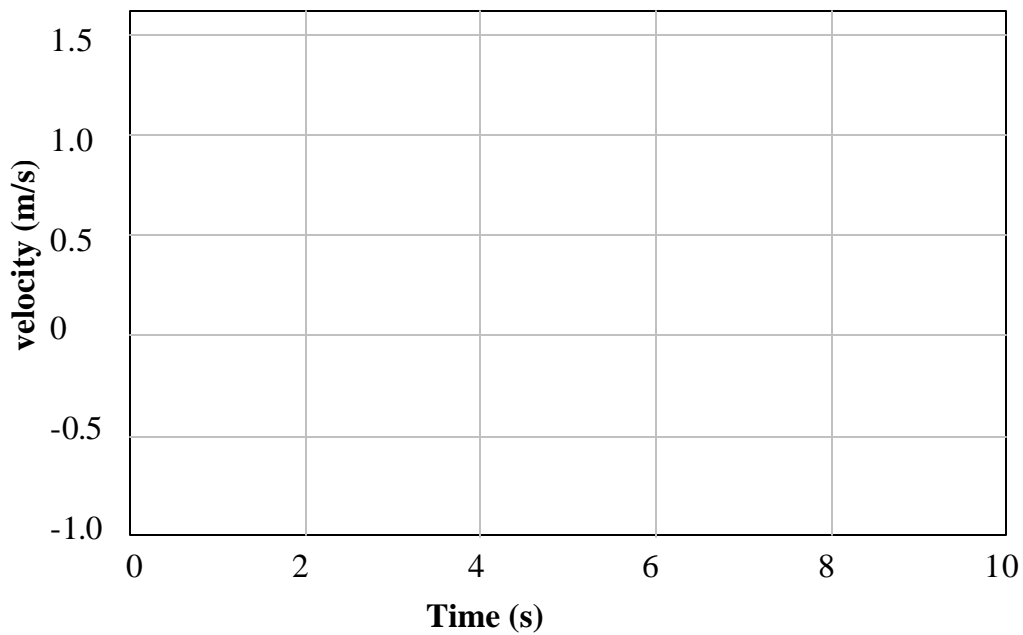
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Acceleration			