PHYSICS 211

Laboratory Orientation

A Practice Lab Consisting of 5 Activities

Note: This is a practice laboratory to help you get acquainted with the equipment and laboratory format. You will get full credit (20 points) for this laboratory provided that you complete all the sections and make a serious attempt to make all the predictions and answer all the questions.

Name: ______________________________

Section: ______________________________

TA: ______________________________

Date: ______________________________

Lab Partners: ______________________________

____

____

Circle the name of the person to whose report your group printouts will be attached. Individual printouts should be attached to your own report.

WHILE WAITING TO START THE LAB, GO AHEAD AND READ THE **INTRODUCTION** TO INVESTIGATION 1, WHICH CONTAINS SOME GENERAL INFORMATION ABOUT THE 211 LABS.

Physics Lab 211-00

Equipment List
Motion detector
Level
211 friction cart
Standard cart track setup:

- Cart track mounted on wooden track base
- Pipe with clamp for elevating track on one end
- C-clamp to secure track base to the table on the other end (2)
- Table clamp to hold the pipe
- Thumbscrews and wing nuts to attach the track base hinge to the pipe clamp (2 each)
- Dual foam cushions held by 2 track barriers on the fixed end of track

Computer File List
MacMotion file "211-00 Distance Plot"
MacMotion file "211-00 Distance Match"
MacMotion file "211-00 Data Entry 1"
MacMotion file "211-00 Velocity Plot"

Key points to note about all of these Laboratories:

- Your TA will visit your group often. If you have any problems, or if you want help with the Lab Questions, ask your TA.

- Interact closely with the other members of your group. To finish these exercises within the allotted time and answer the questions correctly, it will be beneficial for you to coordinate and discuss your activities with other group members.

- Written responses *must* be legible, comprehensible, and as precise as possible in order to receive credit.

- In several places, you will be asked to make predictions regarding experiments. You *will not* be graded on the accuracy of your predictions during each Activity, so don't be concerned if your results don't confirm your predictions. However, you *will* be graded on your reasonable attempt to make the predictions and to answer the questions during each activity.

- You will make several printouts during this lab. In some cases, you will print copies of graphs for each member of the group, and in other cases, you will make a single printout for the entire group. Collect *all group printouts* together at the end of the lab and attach them to *one* group member's lab report. Circle on all reports the name of the person to whose report these group printouts are attached. Printouts may take a couple of minutes and will appear on the printer at the front of the room.

<u>Specific notes for this Laboratory</u>

- "Distance" in the context of this Lab is short for "distance from the motion detector."

- The motion detector is the origin for your distance data. Remember that the origin is the "zero point" from which all distances are measured.

- The motion detector used in this laboratory works by emitting ultrasonic pulses and detecting their reflections from objects such as a cart or your hand. Consequently, when making your graphs, don't move your cart closer than 1/2 meter from the motion detector, since the detectors cannot respond fast enough to emit and detect a pulse for objects closer than about 1/2 meter.

Investigation 1: Distance (Position) vs. Time Graphs of Your Motion

Goals:
- To determine how you can measure your motion with a motion detector.
- To see how your motion looks as a distance (position) vs. time graph.

Introduction: In this investigation, you will use an ultrasonic motion detector to plot a distance (position) vs. time graph of a cart on a track. As you move the cart in front of the motion detector, the graph on the computer screen displays how far from the detector the cart is, the speed of the cart, etc.

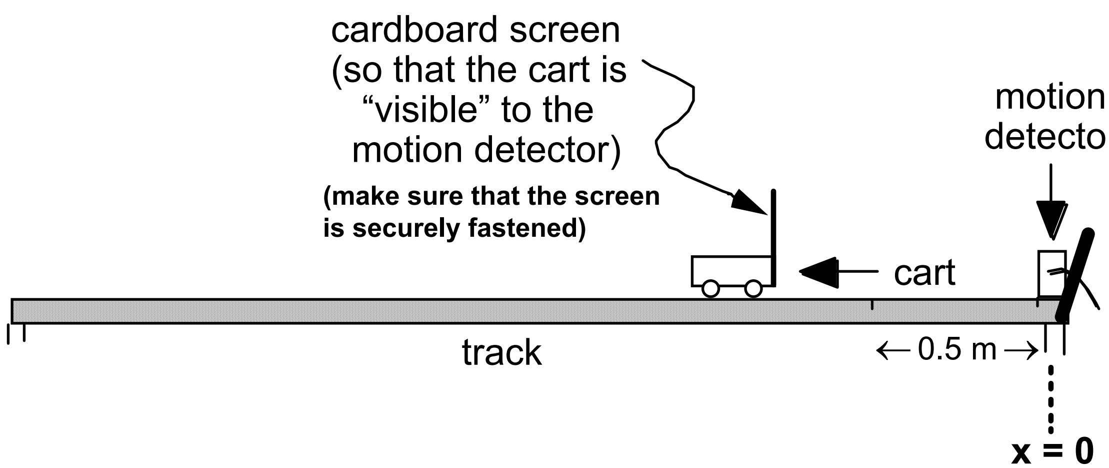


Figure 1. Experimental setup for Investigations 1 and 2

Activity 1: Introduction to "Cart"-ography

Procedure:

1. Open the *MacMotion* program. To start the program, use the mouse to double click on the *MacMotion* icon on the Desktop. The graph axes should appear on the screen.
2. Set up to graph distance. "Pull down" the **File** menu and select **Open...**. Click once on **Desktop**, twice on **211 LAB FILES**, then open the **Lab 0** folder. This is the folder where the files for this lab will be kept. Double click on ***DISTANCE PLOT*** to load it. The distance graph in Figure 2 will appear on the screen.

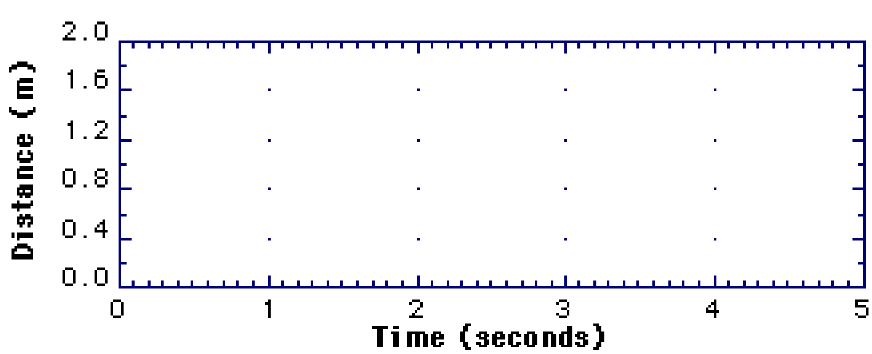
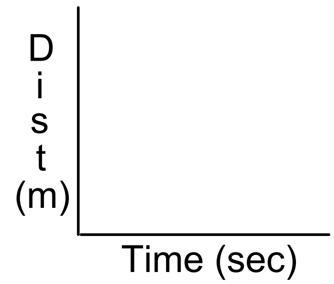


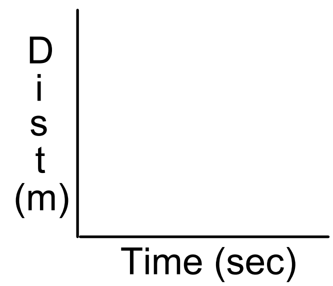
Figure 2. Distance Plot graph format

Predictions: • On graphs (a) through (d) in Figure 3 below, sketch with a dashed line your *predictions* (don't make the measurement yet!) for the distance versus time plots of the cart for each situation described. Make sure that you don't move the cart closer than the 1/2-meter mark while making these graphs.

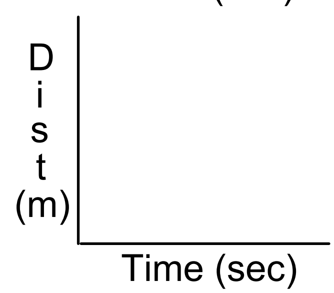
a. The cart moves away from the detector (origin)*slowly and steadily*. Sketch your prediction on the graph to the right.



b. The cart moves away from the detector *medium fast and steadily*.



c. The cart moves toward the detector *slowly and steadily*.



d. The cart moves toward the detector *medium fast and steadily*.

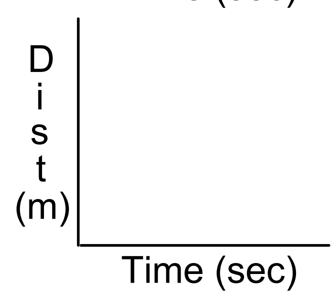


Figure 3. Distance versus time predictions and results for Activity 1

Procedure: (continued)

3. Test your predictions. When you are ready to start graphing distance, click once on the **Start** "button" on the bottom left-hand corner of the screen. Make distance vs. time graphs of the situations described in Figure 3 above by pushing the cart in front of the motion detector with your hand (see Figure 1). Make sure the detector "sees" the cart and not your hand during the motion. Let all members of the group try this activity. Sketch your results with a *solid* line on the graphs provided in Figure 3.

Questions: • Describe the difference between the graph you made by moving the cart away slowly and the one made by moving the cart away more quickly.

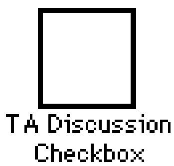
____

____

• Describe the difference between the graph made by moving the cart toward the motion detector and that made by moving the cart away from the motion detector.

____

____



← Get your TA to come over, check and discuss your results, and mark this box.

Activity 2: A Match Made in "Two-Eleven"

Introduction: In this activity you will try to reproduce a distance graph shown on the computer screen by pushing a cart on the track in an appropriate manner.

Procedure:

1. Set up the computer. Select **Open...** from **File** menu. Click once on **Desktop**, twice on **211 LAB FILES**, then open the **Lab 0** folder. Double click on ***DISTANCE MATCH*** to load it. A distance graph similar to Figure 4 will appear on the screen.

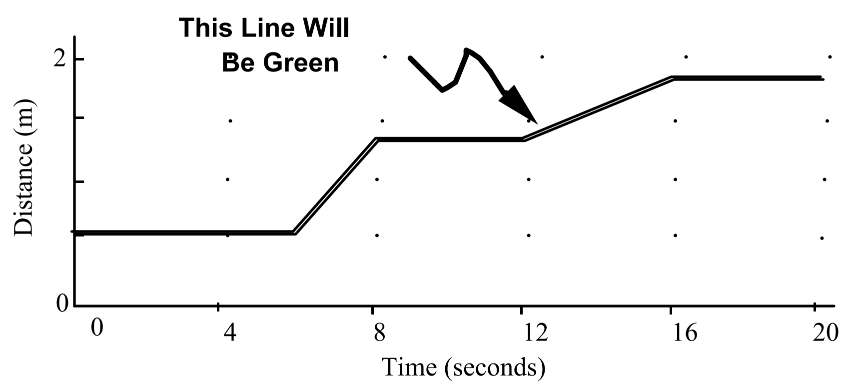


Figure 4. Distance Match graph format

This graph is stored in the computer as "**Data B**." New data from the motion detector are always stored as "**Data A**" and can therefore be collected without erasing the Distance Match graph. "**Data A**" is always plotted in red, while "**Data B**" is always plotted in green. (Clear any data remaining from previous experiments in **Data A** by selecting **Clear Data A** from the **Data** menu.)

Procedure: (continued)

2. Move the cart with your hand to match the distance graph shown on the computer screen. You may try a number of times. Work as a team to coordinate. Make sure the times and distances associated with key features in the distance vs. time plot match the graph provided.

   Each person should do the following:

   - When you have a satisfactory plot, choose **Set Graph Title...** under the **File** menu and enter your name.
   - Choose **Print Graph....**
   - Attach the printout to your own lab report.

Question:

- What was the difference in the way you moved the cart to produce the two differently sloped parts of the graph you just matched?

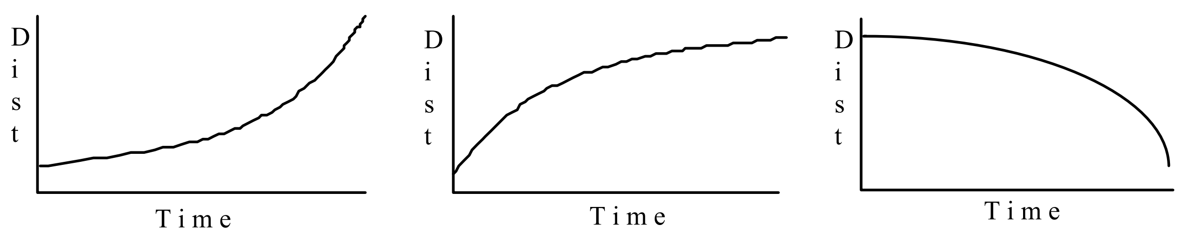
____

____

<u>Activity 3: A Change of Pace</u>

Procedure:

1. Can you make a curved distance vs. time graph?
   - Open ***DISTANCE PLOT*** in the **Lab 0** folder again.
   - Using your hand to move the cart on the track, make each of the graphs shown in Figure 5. All group members should try this.



Graph 1 Graph 2 Graph 3

Figure 5. Distance versus time graphs for Activity 3

Questions:

- Describe how you must move in front of the detector to produce a distance vs. time graph with each of the shapes shown.

Graph 1: ____

____

Graph 2: ____

____

Graph 3: ____

____

Activity 4: Spend Some Time In Analysis

Introduction: In this activity, you will learn how to use *MacMotion* to plot data and to fit these data with simple mathematical expressions.

Procedure:

1. Make a distance vs. time plot of a pushed cart moving medium fast and steadily (either away from or towards the detector).
2. Analyze your results.
   - Record in Table 1 five values of distance, and the associated values of time, from your distance vs. time graph. To obtain these values, choose the **Analyze** menu and select **Analyze Data A**. A vertical line that moves as you move the mouse will appear on your plot. Below the plot you will see the values of distance and time associated with the point at which the vertical line intersects the data. Make sure you select points over a wide range of your data.

Measurement Number	Distance [m] x	Time [sec] t
1		
2		
3		
4		
5		

Table 1. Cart position and time for Activity 4

   - Use the graph in Figure 6 below to plot the selected distance vs. time points recorded in Table 1. *Label the axes* appropriately, *draw* a "best fit" line through your data points, and *determine the slope* of this line. Write this slope value to the right of your plot for later comparison.

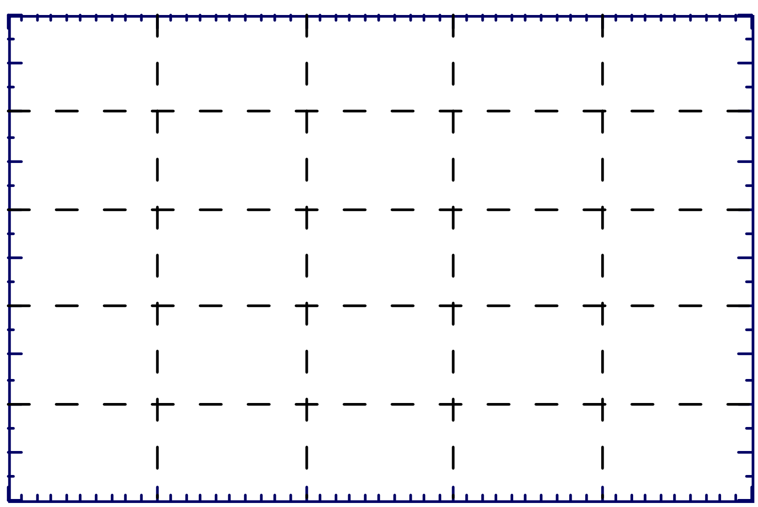


Figure 6. Plot of distance vs. time values from Table 1

Procedure: 3. Now, plot and fit your data in Table 1 using *MacMotion*.

- Plot the points in Table 1. A file for plotting your data, ***DATA ENTRY 1***, has been put in the **Lab 0** folder. **Open** this file under the **File** menu.
- Select **Data A Table** under the **Windows** menu. You should see a new window labeled "Data A" similar to that shown in Figure 7. You can enter numerical data directly into the table in the spaces shown.

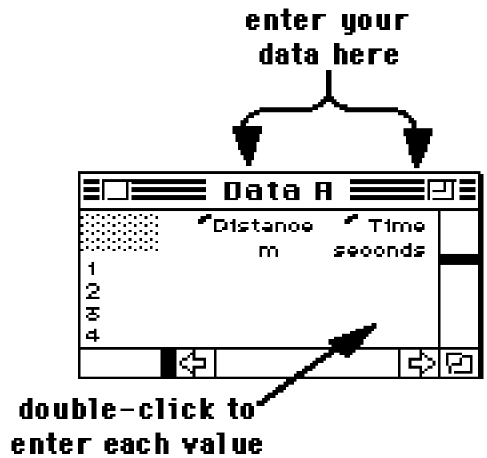


Figure 7. Data Entry table for entering distance and time values

- Record your four or five distance and time values in the two columns in the on-screen table, as shown in Figure 7. To enter a value into a location (or modify the location), double-click on it, type in your number, and type Return or Enter when you're done. This will also move you down one box on the screen. You may also use the arrow keys to "move around."
- When all your data has been entered, click once on the graph window to bring it to the front and view your points.
- Double-click on the graph window and adjust the scale by changing the x- and y-axis limits so that your points are visible and so that there is not a lot of blank space.

Procedure: (continued)

4. Create a fit to your data. Select **Fit...** under the **Analyze** menu. A dialog box like that in Figure 8 will appear, where you can specify the mathematical formula to try.

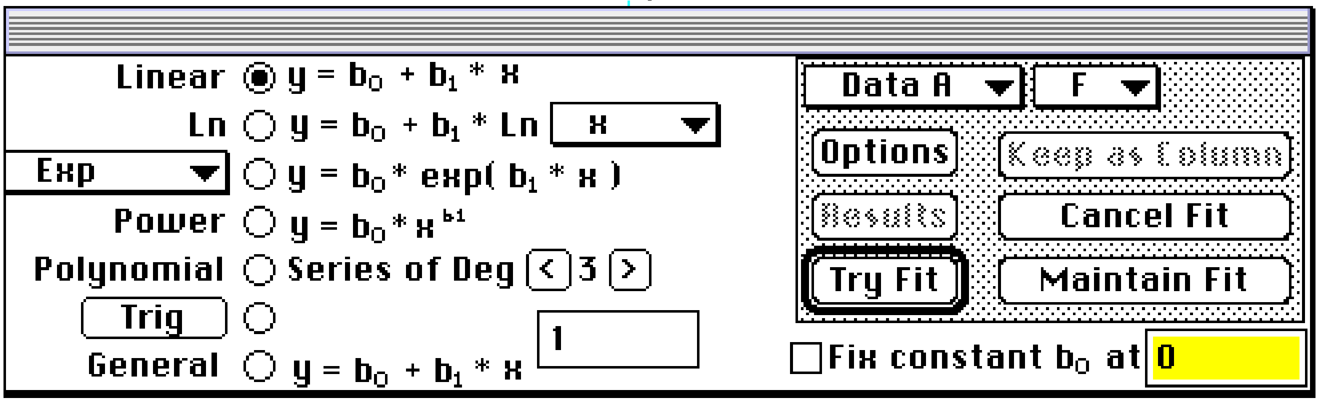


Figure 8. Dialog box for defining a fitting function

- Make sure that **Linear** is selected (since your plot should be linear), as in Figure 8, and then click on **Maintain Fit**. You should now see a straight line on top of your graph. The computer has tried to draw a "best fit" through all the data points. If it doesn't look right, try to figure out what went wrong or ask your TA.
- Re-adjust the scale of your display if necessary to better view the points.

NOTE: The computer displays the formula of the fitted line in the upper right-hand corner, in terms of the generic variables *y* and *x* . From this you can get the values of b_1 and b_0 (the slope and intercept, respectively) for the fitted line shown.

Below, record the slope of the "best fit" through your data:

b_1 = ________

Questions:

- What physical quantity does this slope represent, and what is your measured value (include units) for this quantity? Record your answers in Table 2.

Quantity	Measured Value

Table 2: Activity 4 Results

- How does this value compare with the slope you estimated from the "best" fit to your plot of the data? If there is a significant difference, explain why.

____

____

TA Discussion Checkbox

Investigation 2: Velocity vs. Time Graphs of Your Motion

Goals: • To determine the relationship between velocity and your actual motion.

• To see how your motion looks on a velocity vs. time graph.

Introduction: You have already plotted your distance (position) from the motion detector as a function of time. You can also plot how fast you are moving. How fast you move is your *speed*. It is the rate of change of distance with respect to time. *Velocity* takes into account your speed and the direction you are moving. When you measure motion along a line, velocity can be positive or negative. As you do this investigation, try to learn how this sign corresponds to direction.

Activity 5: Watch Your Speed

Procedure: 1. Set up to graph distance and velocity. Pull down the **File** menu and select **Open.** Click once on **Desktop**, twice on **211 LAB FILES**, then twice again on the **Lab 0** folder. Double click on ***VELOCITY PLOT*** to load it. Distance and velocity graphs similar to those in Figure 9 will appear on the screen.

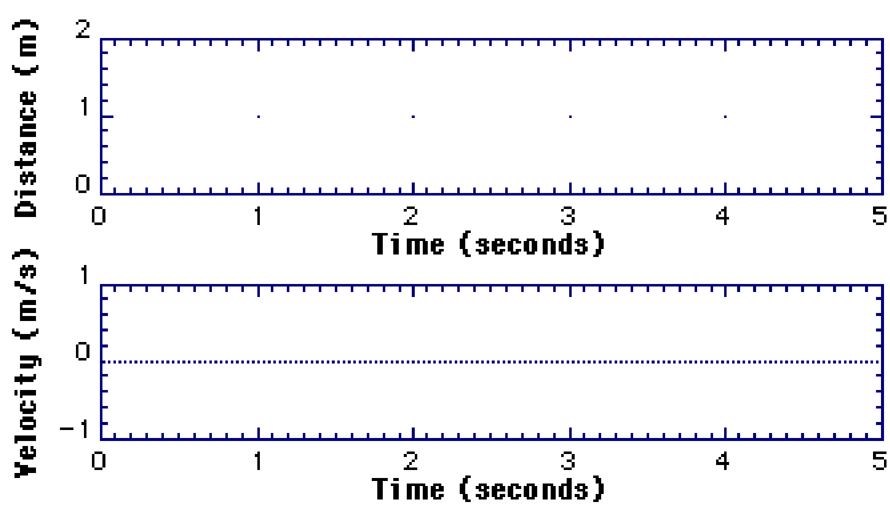


Figure 9. Distance and velocity versus time graph format for Activity 5

Procedure: (continued)

2. Graph your velocity for different speeds and directions.

   a. Make distance and velocity graphs by pushing a cart away from the detector *slowly and steadily*. Repeat until you get a good graph.

   You may want to change the scales so that the graph fills more of the screen and is clearer. To do this, double click anywhere on the graph and change the range of numbers on the vertical or horizontal scales.

   Sketch your results below in Figure 10 (try to understand unexpected wiggles; ask your TA for help if the cart or sensor behave inexplicably).

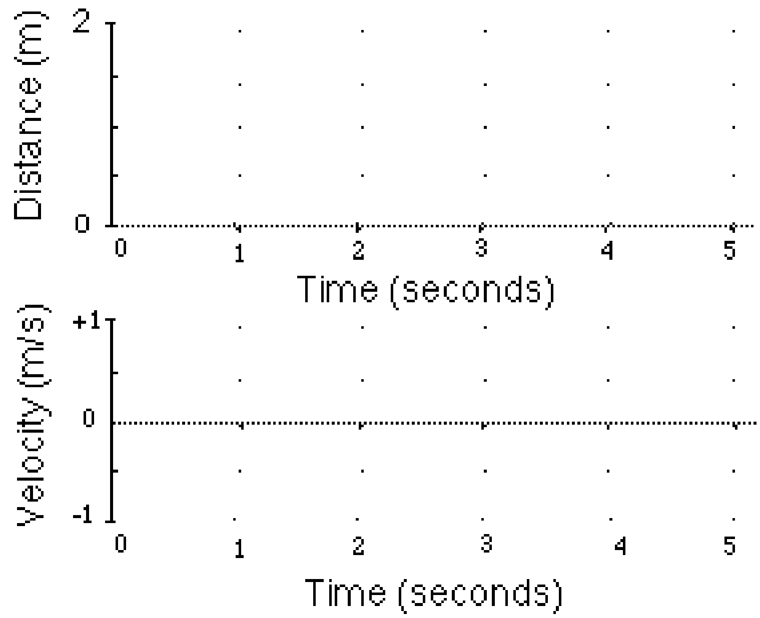


Figure 10. Slow and steady motion away from the detector

   b. Make distance and velocity graphs while pushing the cart away from the detector medium fast and steady. Sketch your results in Figure 11.

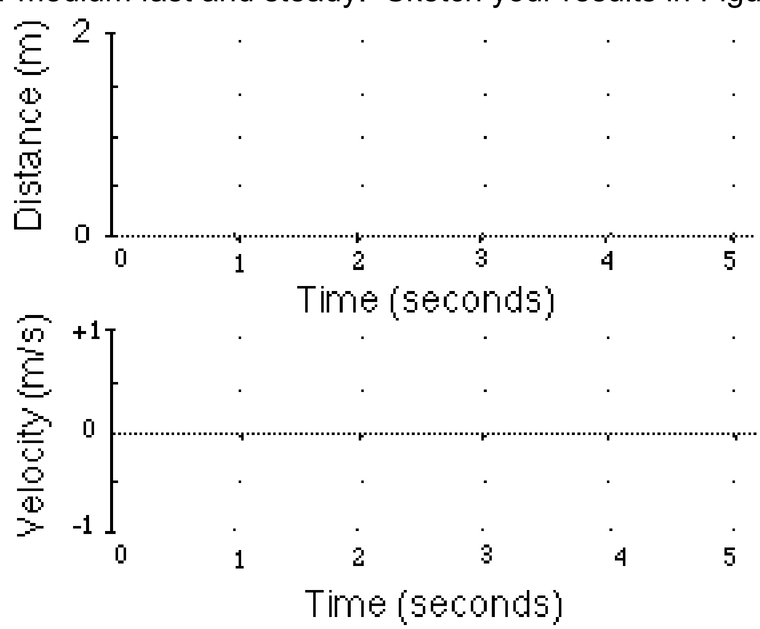


Figure 11. Medium fast and steady motion away from the detector

Procedure:
(continued)

c. Make distance and velocity graphs while moving the cart toward the detector slowly and steadily. Sketch your graphs in Figure 12.

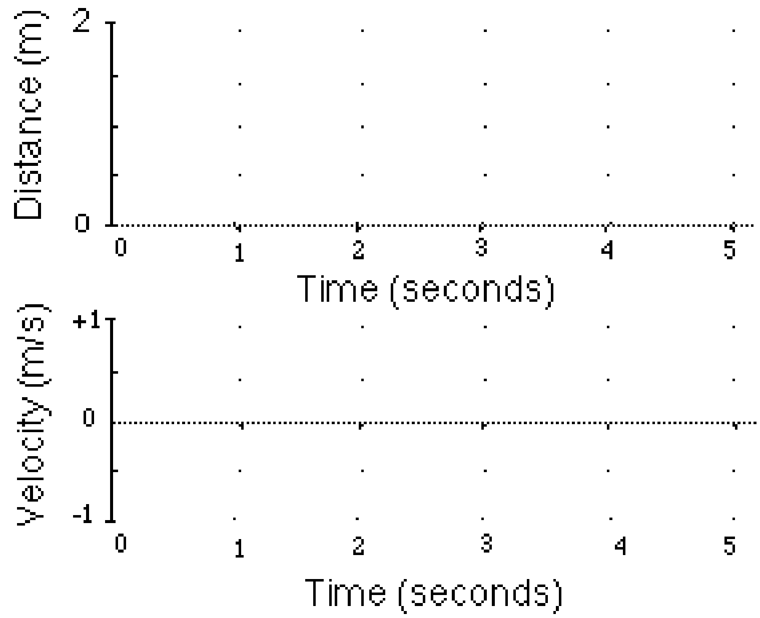


Figure 12. Slow and steady motion toward the detector

d. Make distance and velocity graphs while moving the cart toward the detector medium fast and steady. Sketch your graph in Figure 13.

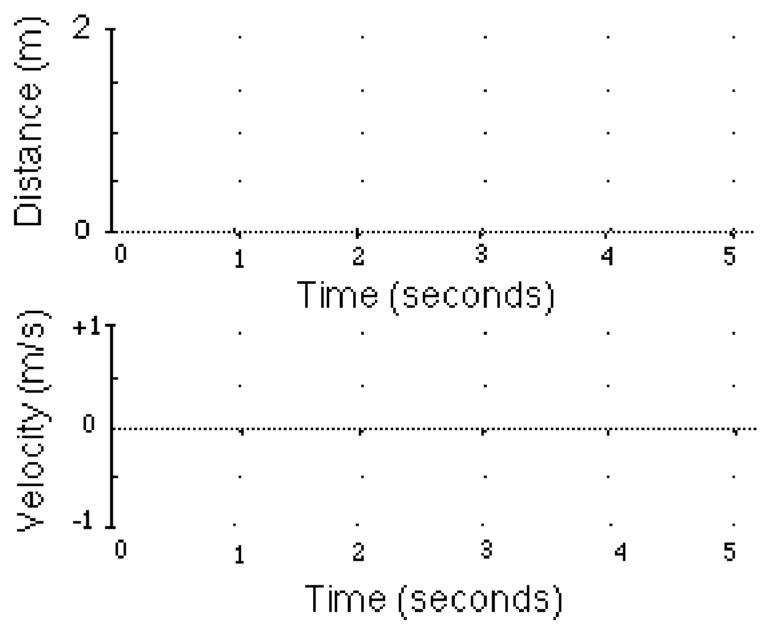


Figure 13. Medium fast and steady motion toward the detector

Questions:

- What is the most important difference between the graph made by moving the cart away from the detector slowly and the one made by moving it away more quickly?

  ____

  ____

- How are the velocity vs. time graphs different for motion away and motion toward the detector?

  ____

  ____