Phys 135A Activity 1

Name________________________________

Class________________________________

Lab Partners ___________________________

INTRODUCTION TO MOTION

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

To find out How you can measure your motion with a motion detector

How your motion looks as a distance (position)-time graph

Introduction In this investigation, you will use a motion detector to plot a distance (position)-time graph of your motion. As you walk (or jump, or run), the graph on the computer screen displays how far away from the detector you are.

- *"Distance" is short for "distance from the motion detector."*
- The motion detector is the *origin* from which distances are measured.
- It detects the closest object directly in front of it (including your arms if you swing them as you walk).
- It will not correctly measure anything closer than 1/2 meter. When making your graphs don't go closer than 1/2 meter from the motion detector.

Activity 1 Making Distance-Time Graphs

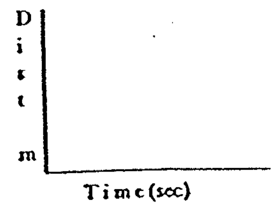
1. Connect the Logger Pro interface to your computer and a motion detector. Connect the power cord (you should hear melodious beeping which will indicate that the device is ready to run).

2. Turn on the Logger Pro software on the desktop.

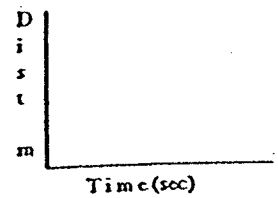
3. Open the program called "1 distance-time." Dr. Zorba will describe to you how you can do that.

4. <u>Make distance-time graphs for different walking speeds and directions.</u>

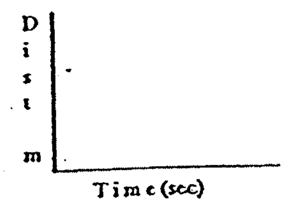
a. Start at the 1/2-meter mark and make a distance/time graph, walking away from the detector *slowly and steadily*. Sketch the graph on the right.



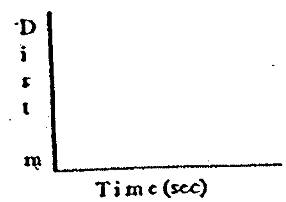
b. Make a distance/time graph, walking away from the detector *medium fast and steadily*. Sketch the graph.



c. Make a distance/time graph, walking toward the detector *slowly and steadily*. Sketch the graph.



d. Make a distance/time graph, walking toward the detector *medium fast and steadily*. Sketch the graph.



Questions

Describe the difference between the graph you made by walking away slowly and the one made by walking away more quickly. (Q1)

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Describe the difference between the graph made by walking toward and the one made walking away from the motion detector. (Q2)

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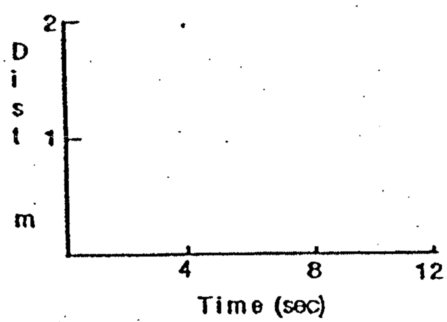
Prediction

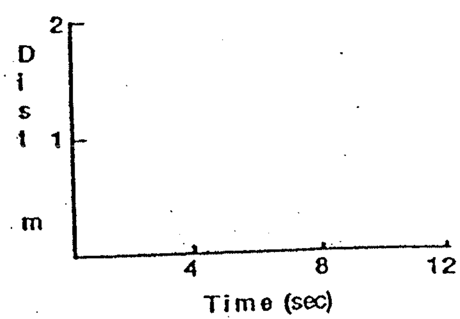
Predict the graph produced when a person starts at the 1-meter mark, walks away from the detector *slowly and steadily* for 4 seconds, stops for 4 seconds, and then walks toward the detector *quickly*. Draw your *prediction* on the left axes below using a *dotted line*.

Compare predictions with the rest of your group. See if you can all agree. Draw your group's prediction on the left hand axes using a *solid line*. (Do not erase your original prediction.)

PREDICTION



FINAL RESULT



5. Do the experiment. Move in the way described and graph your motion. When you are satisfied with your graph, draw your group's final result on the right axes.

Question

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*. (Q3)

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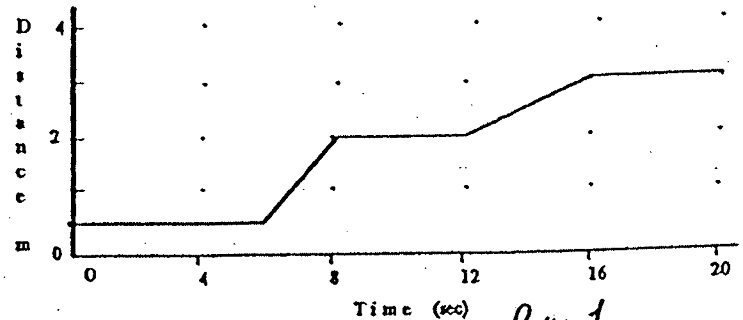
Activity 2

Matching a Distance Graph

In this activity you will match a distance graph shown on the computer screen.

1. Display the distance graph on the screen. Pull down the File Menu and select **Open**. Double click on **Distance.Match**. The distance

graph below will appear on the screen.



Run 1

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. (Clear any data remaining from previous experiments ~~in Data A~~ by selecting ~~Clear Data A~~ from the Data Menu.) Run 2, Run 3, ...

Delete Run 2 (for...

2. Move to match the distance graph shown on the computer screen. You must move to duplicate the **Distance.Match** graph. You may try a number of times. Work as a team. Get the times right. Get the distances right. Each person should take a turn.

Question What was the difference in the way you moved to produce the two differently sloped parts of the graph you just matched? (Q4)

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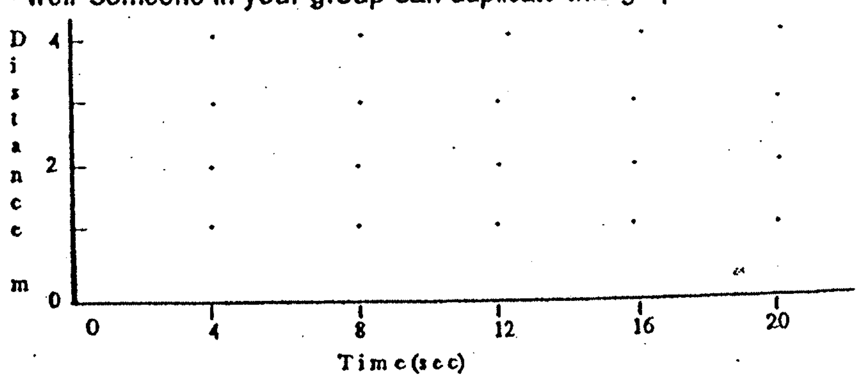
Activity 3 **Other Distance-Time Graphs**

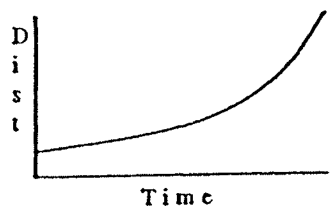
It will be less confusing if you remove the **Distance.Match** graph from the screen before doing the exercises below. To do this, select **Clear Data B** from the Data Menu.

1. Make up your own distance(postition)-time graph. Use straight lines, no curves. Sketch the graph below with a dashed line. Now see how well someone in your group can duplicate this graph on the screen.

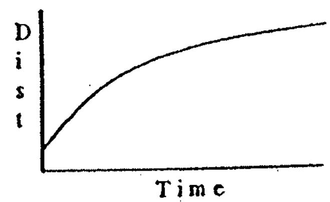


Draw the best attempt by a group member to match your distance-time graph on the same axes. Use a solid line.

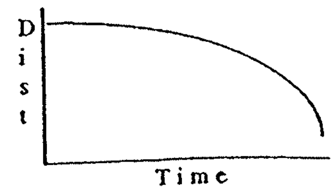
2. <u>Can you make a curved distance-time graph?</u> Try to make each of the graphs shown below.



Graph 1



Graph 2



Graph 3

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

Graph 1 answer: ______________________________

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Graph 2 answer: ______________________________

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Graph 3 answer: ______________________________

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INTRODUCTION TO MOTION

Investigation 2: Velocity-Time Graphs of Your Motion

To find out The connection between velocity and your actual motion
How your motion looks as a velocity-time graph

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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.

Activity 1 **Making Velocity Graphs**

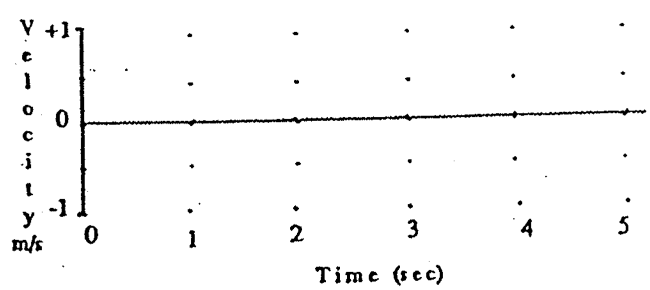
1. <u>Set up to graph velocity.</u> Double click anywhere on the distance graph to display the dialog box. Then select **Velocity** for the vertical axis and set the range from **-1** to **1** m/sec. Also change the **Time** scale to read **0** to **5** sec.

2. <u>Graph your velocity for different walking speeds and directions</u>.

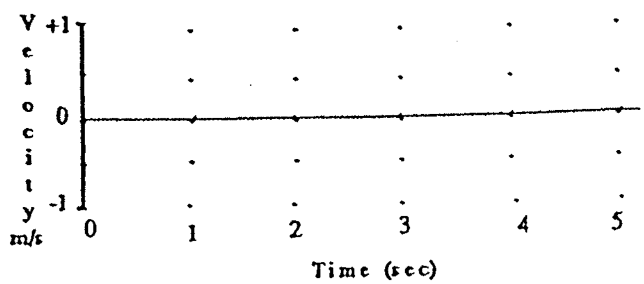
   a. Make a velocity graph by walking *away* from the detector *slowly and steadily* . Try again until you get a graph you're satisfied with.

      You may want to change the velocity scale so that the graph fills more of the screen and is clearer. To do this, double click anywhere on the graph and change the velocity range.

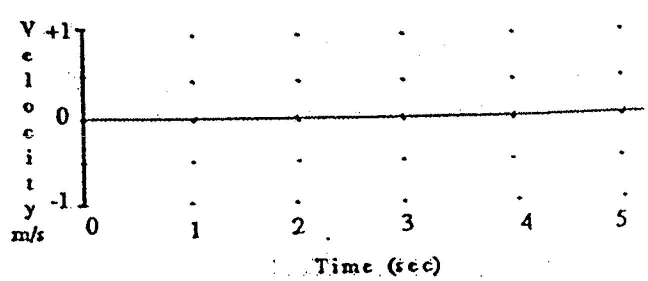
      Sketch your result below. (Just draw *smooth* patterns; leave out smaller bumps that are mostly due to your steps.)



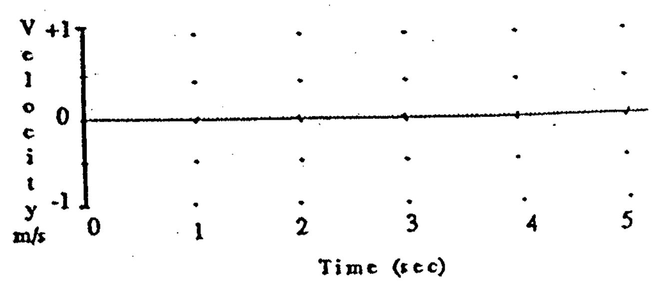
b. Make a velocity graph, walking *away* from the detector *medium fast and steadily.* Sketch your graph.



c. Make a velocity graph, walking *toward* the detector *slowly and steadily.* Sketch your graph.



d. Make a velocity graph, walking *toward* the detector *medium fast and steadily* . Sketch your graph.



Questions

What is the most important difference between the graph made by slowly walking away from the detector and the one made by walking away more quickly? (Q1)

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How are the velocity-time graphs different for motion away and motion toward the detector? (Q2)

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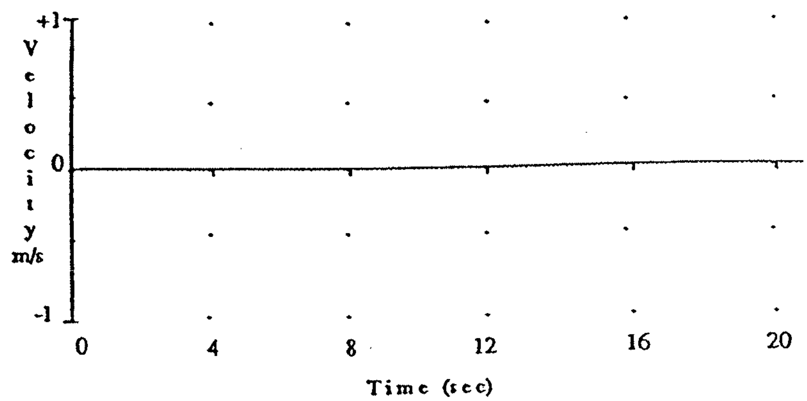
3. Predict a velocity graph for a more complicated motion and check your prediction.

   a. Each person draw below, using a *dotted line*, your *prediction* of the velocity graph produced if you—
      - walk away from the detector slowly and steadily for 10 seconds
      - stop for 4 seconds
      - walk toward the detector steadily about twice as fast as before

   b. Compare predictions and see if you can all agree. Use a solid line to draw in your group prediction.

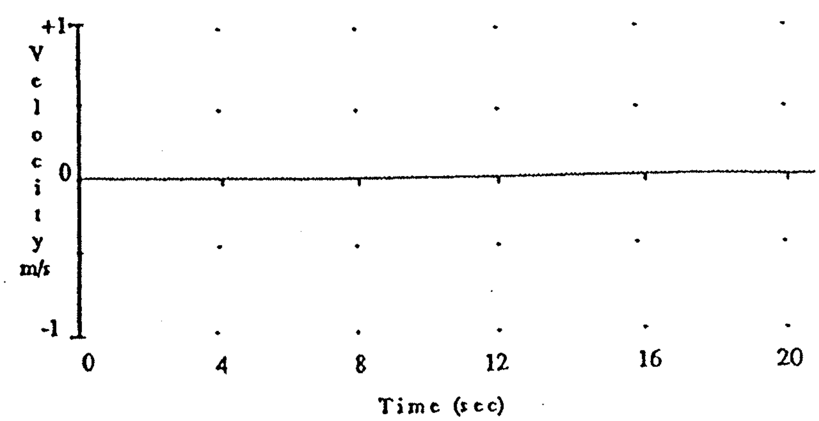
Prediction



4. Do the experiment. (Be sure to adjust the time scale to 20 seconds. To do this double click anywhere on the graph and change the time scale.) Repeat your motion until you think it matches the description.

   Draw the best graph on the axes below. Be sure the 4-second stop shows clearly.

Final Result



Comment

How fast you move is your speed, the rate of change of distance with respect to time. Velocity implies both speed and *direction.* As you have seen, for motion along a line (the positve x axis) the sign (+ or -) of the velocity indicates the direction. If you move away from the detector (origin), your velocity is positive, and if you move toward the detector, your velocity is negative.

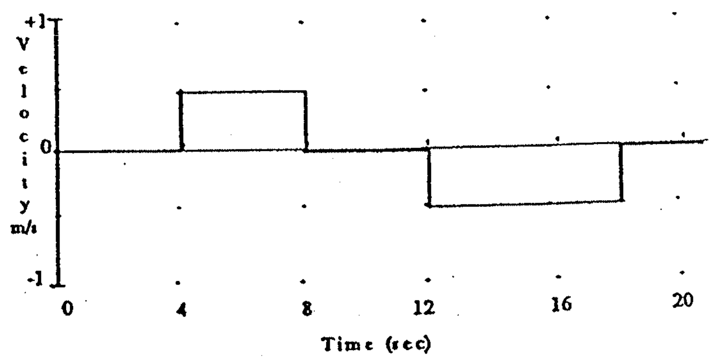
The faster you move *away* from the origin, the larger positive number your velocity is. The faster you move *toward* the origin, the "larger" negative number your velocity is. That is -4 m/s is twice as fast as -2 m/s and both motions are toward the origin.

Activity 2

Matching a Velocity Graph

In this activity, you will move to match a velocity graph shown on the computer screen.

1. Display the velocity graph on the screen. Pull down the File Menu and select **Open.** Then double click on **Velocity.Match.** The velocity graph below will appear on the screen.



2. Move so as to imitate this graph. You may try a number of times. Work as a team and plan your movements. Get the times right. Get the velocities right. Each person should take a turn.

   Draw in your group's best match on the axes above.

Questions

Describe how you moved to match each part of the graph. (Q3)

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Is it possible for an object to move so that it produces an absolutely vertical line on a velocity time graph? Explain. (Q4)

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INTRODUCTION TO MOTION

Investigation 3: Distance and Velocity Graphs

To find out The relationship between distance-time and velocity-time graphs.

Introduction You have looked at distance- and velocity-time graphs separately. Now you will see how they are related.

Activity 1 **Predicting Velocity Graphs from Distance Graphs**

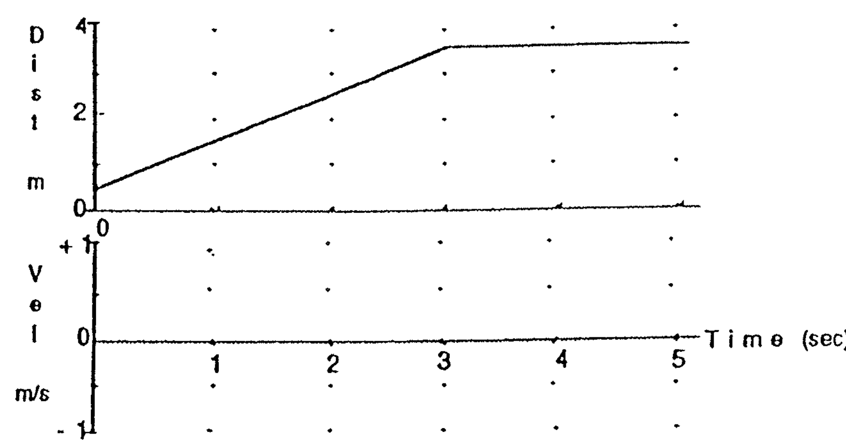
1. Set up to graph Distance and Velocity. Pull down the Display Menu and select **Graph Layout.** Select **Two Graphs** and click on OK. Double click on the top graph and set it up to display **Distance** from **0** to **4** m for a time of **5** sec. Then set up the bottom graph to display **Velocity** from **-1** to **1** m/sec for **5** sec. Clear any previous graphs.

2. Predict a velocity graph from a distance graph. Carefully study the distance graph shown below and predict the velocity-time graph that would result from the motion. Using a *dotted line*, sketch your *prediction* of the corresponding velocity-time graph on the velocity axes.

3. Make the graphs. After each person has sketched a prediction, **Start,** and do your group's best to make a distance graph like the one shown below. Walk as smoothly as possible.

   When you have made a good duplicate of the distance graph, sketch your actual graph over the existing distance-time graph.

   Use a *solid line* to draw the actual velocity graph on the same graph with your prediction. (Do not erase your prediction).



Questions

How would the distance graph be different if you moved faster? Slower? (Q1)

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How would the velocity graph be different if you moved faster? Slower? (Q2)

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Activity 2 **Estimating and Calculating Velocity**

In this activity, you will estimate an average velocity from the velocity graph in Activity 1 and then calculate an average velocity using your distance graph .

1. Estimate your average velocity from your velocity graph in Activity 1. You are to estimate a single average velocity while you were walking steadily in Activity 1. Select **Analyze** in the Data Menu, read a number of values (say ten) from the velocity graph, and use them to calculate the average (mean) velocity.

   Velocity values read from graph (m/s): ____ ____ ____ ____ ____

   ____ ____ ____ ____ ____

   Average value of the velocity: _______m/s

Comment

Average velocity during a particular time interval is the change of distance divided by the change in time. By definition, this is also the (average) *slope* of the distance-time graph for that time period.

As you have observed, the faster you move, the more inclined is your distance-time graph. The *slope* of a distance-time graph is a quantitative measure of this incline, and therefore it tells you the velocity of the object.

2. Calculate your average velocity from your distance graph in Activity 1. Use **Analyze** to read the distance and time coordinates for two typical points while you were moving. For a more accurate answer, use two points as far apart as possible but still typical of the motion.

   Point 1 Distance _______ m Time ________ sec

   Point 2 Distance _______ m Time ________ sec

   Calculate the change in distance between points 1 and 2. Also calculate the corresponding change in time (time interval). Divide the change in distance by the change in time to calculate the *average* velocity. Show your calculations below.

   Change in distance:_______m Change in time:_______sec

   Average velocity :_______m/s

3. Draw in the average velocity you just calculated on the velocity graph in Activity 1.

Questions

Is the average velocity positive or negative? Is this what you expected? (Q3)

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Does the average velocity you just calculated from the distance graph agree with the average velocity you estimated from the velocity graph? Do you expect them to agree? How would you account for any differences? (Q4)

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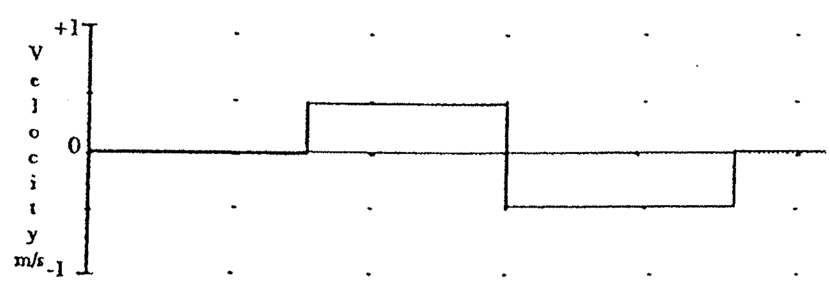
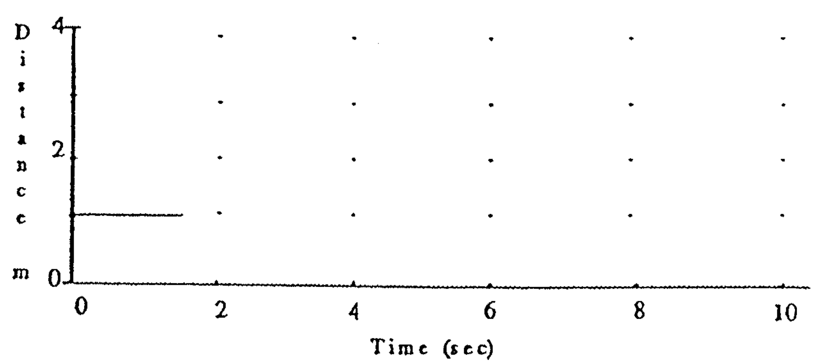
Activity 3 Predicting Distance Graphs from Velocity Graphs

1. Predict a distance(position)-time graph from a velocity-time graph. Carefully study the velocity graph below. Using a *dotted line*, sketch your *prediction* of the corresponding distance graph on the bottom set of axes. (Assume that you started at the 1-meter mark.)





2. Make the graphs. After each person has sketched a prediction do your group's best to duplicate the top (velocity-time) graph by walking. (Reset the **Time** scale to 10 sec before you start.)

   When you have made a good duplicate of the velocity-time graph, draw your actual result over the existing velocity-time graph.

   Use a *solid line* to draw the actual distance-time graph on the same axes with your prediction. (Do not erase your prediction.)

Questions

How can you tell from a velocity-time graph that the moving object has changed direction? (Q5)

What is the velocity at the moment the direction changes? (Q6)

Is it possible to actually move your body (or an object) to make the vertical lines on the velocity graph you were trying to match? Why or why not? (Q7)

Is it possible to actually move your body (or an object) to make vertical lines on a distance-time graph? Why or why not? What would the velocity be for a vertical section of a distance-time graph? (Q8)

How can you tell from a distance-time graph that your motion is steady (motion at a constant velocity)? (Q9)

How can you tell from a velocity-time graph that your motion is steady? (Q10)