Activity
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Velocity Test: Interpreting Velocity Graphs

When you walk, ride a bike, or travel in a car, you are often interested in the distance traveled, the time it took, and the speed or velocity of your motion. In this activity, you will learn more about how these four quantities are related.

Speed and velocity are often confused since the terms are sometimes used interchangeably, but they are not the same thing. So what is the difference? *Speed* is how far you have gone, divided by the time it took to move. In other words, speed tells how fast you are traveling, but without regard to direction. Since the distance you have traveled is always positive, speed is always positive.

On the other hand, *velocity* is the rate of change of position. Position is the directed distance from a chosen starting point, or origin. If we consider only motion on the positive side of the origin, motion away from the origin is a positive change in position, while motion toward the origin is a negative change in position. Velocity can, therefore, be either positive or negative depending upon your direction of motion. The data from a Motion Detector is a directed distance, so it can easily be used to calculate velocity.

Velocity is defined as the change in position divided by the change in time, or

$$v \equiv \frac{\Delta d}{\Delta t} = \frac{d_2 - d_1}{t_2 - t_1}$$

Here, d_1 and d_2 are your positions at two particular times t_1 and t_2. This definition should look familiar, for it has exactly the same form as that of slope for a y versus x graph, or

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

If you look at a plot of distance from the detector, which is position as a function of time, the velocity is the slope of that graph. For simple distance graphs you can find the slope of a segment of the graph to find the corresponding velocity during that time interval. In this activity, you will calculate a few velocities from a distance graph and compare them to the velocity graph produced by the calculator.

OBJECTIVES

- Record distance versus time data for a simple motion of a walker.
- Analyze the distance versus time data to sketch the form of a corresponding velocity versus time graph.
- Compare this velocity graph with the velocity graph determined by the calculator.

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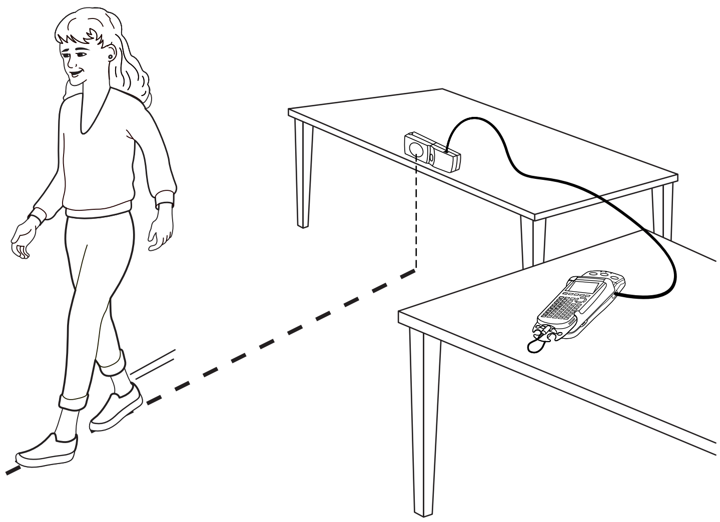
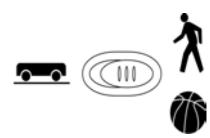
MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator
Vernier EasyData application
CBR 2 or Go! Motion and direct calculator cable
or Motion Detector and data-collection interface



PROCEDURE

1. Set up the Motion Detector and calculator.
   a. Open the pivoting head of the Motion Detector. If your Motion Detector has a sensitivity switch, set it to Normal as shown.



   b. Turn on the calculator and connect it to the Motion Detector. (This may require the use of a data-collection interface.)

2. Place the Motion Detector on the edge of a table about waist level, pointing into an open area. You will need at least 2 meters unobstructed space to walk in front of the detector.

3. Set up EasyData for data collection.
   a. Start the EasyData application, if it is not already running.
   b. Select File from the Main screen, and then select **New** to reset the application.

4. For this activity you need a position versus time graph that shows both positive and negative slope, but you do not want it to be too complicated. Stand about 1 m in front of the Motion Detector. After you hear the clicking start, stand still for about a second. Then walk slowly away for about two seconds at a uniform rate, and then walk toward the detector for the remaining time. Do not get any closer than 50 cm from the detector.

   When you are ready, select Start to begin data collection and walk as described above. Data collection will run for five seconds.

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5. When data collection is complete, a graph of distance versus time will be displayed. Examine the graph. This graph should start with a nearly horizontal region, followed by a fairly linear increase, followed by a fairly linear decrease.

   Check with your teacher if you are not sure whether you need to repeat the data collection. To repeat data collection, select **Main** and repeat to Step 4.

ANALYSIS

1. Use the cursor keys and the distance versus time plot to determine the time interval when the velocity is positive. In other words, when is the slope of the distance versus time graph positive?

⇒ Record the starting and ending times in Question 1 on the *Data Collection and Analysis* sheet. Answer Questions 2 and 3.

2. The several time intervals you just identified will let you describe the distance versus time graph using just four points. There should be three roughly linear segments:

   - The first segment runs from $t_1 = 0$ s to some time later that we will call t_2.
   - The next segment starts at t_2 and runs to time t_3 when you changed direction.
   - The last segment runs from t_3 to the end of the data collection, which we will call t_4.

   The distance information at each of these four times will allow you to calculate a velocity for each time interval.

   Trace across the distance graph using the cursor keys, and find the x and y coordinates of the four points. Round all values to two decimal places and record the values in the Data Table on the *Data Collection and Analysis* sheet.

⇒ Answer Questions 4–6 on the *Data Collection and Analysis* sheet.

3. EasyData can display its velocity versus time graph. To view the velocity versus time graph, select **Plots**, and then select **Vel vs Time**.

⇒ Answer Questions 7–10 on the *Data Collection and Analysis* sheet.

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DATA COLLECTION AND ANALYSIS

Name ______________________________

Date ______________________________

DATA TABLE

<table>
<tr><th></th><th>t</th><th>d</th><th rowspan="2"></th><th rowspan="2"></th></tr>
<tr><td rowspan="2">point 1</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td rowspan="2">slope segment 1</td><td rowspan="2"></td></tr>
<tr><td rowspan="2">point 2</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td rowspan="2">slope segment 2</td><td rowspan="2"></td></tr>
<tr><td rowspan="2">point 3</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td rowspan="2">slope segment 3</td><td rowspan="2"></td></tr>
<tr><td rowspan="2">point 4</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td></td><td></td></tr>
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QUESTIONS

1. Record the starting and ending times when the velocity is positive.

2. Identify all intervals where the velocity is negative. Explain how you know the velocity values are negative for these intervals.

3. What portions of the graph represent a velocity of zero? Explain your answer.

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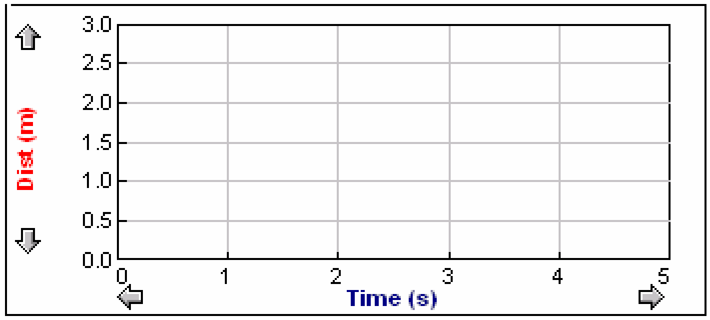
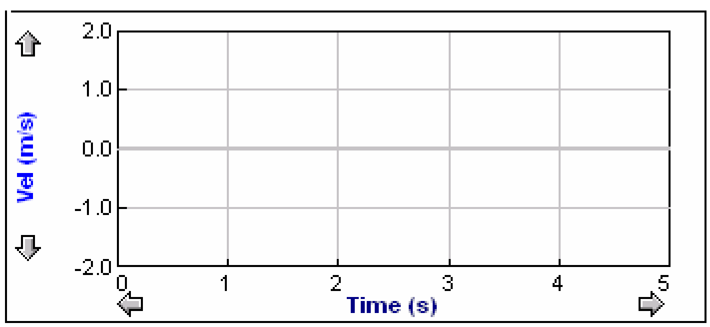
4. Make a sketch of the distance versus time graph using just the three segments you have extracted from the raw data. Use the frame provided below for your sketch.



5. Calculate the slope of the each of the three segments and enter them in the Data Table. Note that the slope is just the velocity during the corresponding time interval. What are the units of the slope?

6. Now use the slopes of the three segments to sketch a velocity versus time graph. Since each slope is also a velocity value for that time interval, the velocity graph will consist of three horizontal lines at various heights.



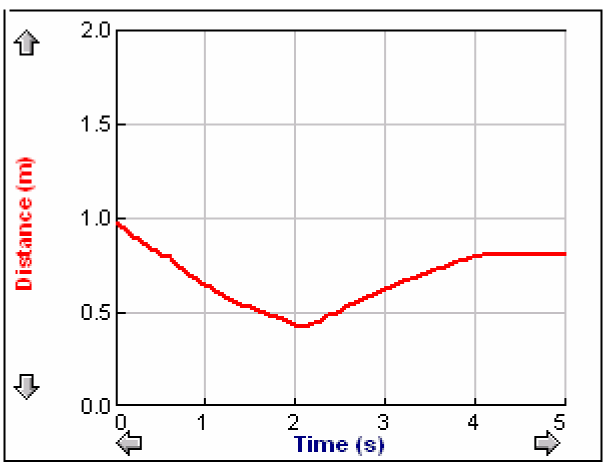
7. How does the calculator's graph compare to yours?

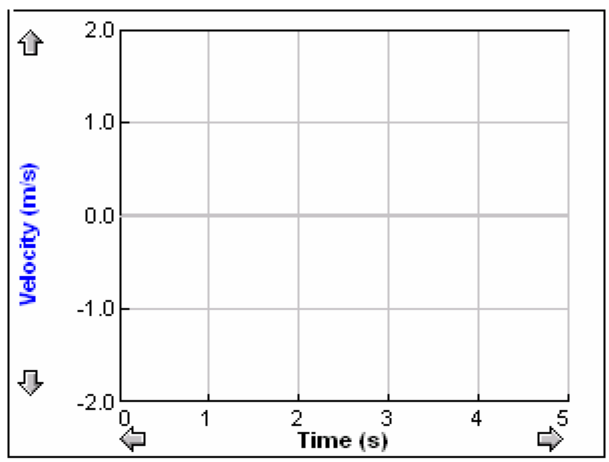
8. Why might the calculator's graph and your graph be different? **Hint:** Does the calculator use just three segments to find slopes?

9. Complete the following table showing characteristics of a velocity graph for specific kind of motion.

Actual Motion	Velocity Graph Characteristic
Person moves towards the detector	
Person stands still	
Person moves away from the detector	

10. Look at the distance versus time plot of a walker (below, left). Describe the motion of the walker in as much detail as possible in the space below. Sketch the corresponding velocity versus time graph in the axes provided.





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