Graphing Your Motion

Graphs made using a Motion Detector can be used to study motion. In this experiment, you will use a Motion Detector to make graphs of your own motion.

OBJECTIVES

In this experiment, you will

- use a Motion Detector to measure distance and velocity
- produce graphs of your motion
- analyze the graphs you produce
- match distance *vs*. time and velocity *vs*. time graphs

MATERIALS

LabPro or CBL 2 interface	Vernier Motion Detector
TI Graphing Calculator	masking tape
DatMatch program	meter stick

walk back and forth
in front of
Motion Detector
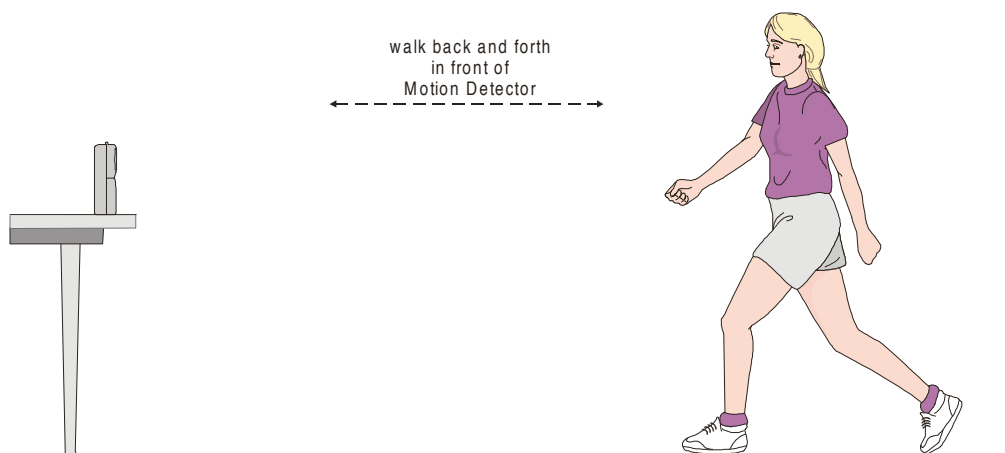
PROCEDURE

Part I Distance *vs*. Time Graphs

1. Fasten a Motion Detector to a tabletop facing an area free of furniture and other objects. The Motion Detector should be at a height of about 15 cm above your waist level.

2. Use short strips of masking tape on the floor to mark the 1-m, 2-m, 3-m, and 4-m distances from the Motion Detector.

3. Plug the Motion Detector into the DIG/SONIC 1 port of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

4. Turn on the calculator and start the DATMATCH program. Press [CLEAR] to reset the program.

5. Set up the calculator and interface for data collection.

    a. Use [▲] and [▼] to select MODE.
    b. Press [ENTER] to change the mode to TIME GRAPH.

6. Explore making distance *vs.* time graphs.

    a. Stand at the 1.0-m mark, facing away from the Motion Detector.
    b. Signal your partner to select START.
    c. Slowly walk to the 2.5-m mark and stop.
    d. When data collection ends, select DISTANCE from the SELECT GRAPH menu.
    e. Sketch your graph on the empty graph provided below.
    f. Press [ENTER] to return to the SELECT GRAPH menu.
    g. Select RETURN TO MAIN SCREEN to return to the main screen.

7. Repeat Step 6 while walking faster. Sketch your new line on the same graph.

PROCESSING THE DATA (Part I)

1. Describe the differences between your two graphs.
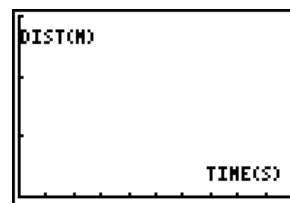
Part II Matching Distance *vs.* Time Graphs

8. Set up the calculator and interface for distance *vs.* time graph matching.

    a. Use [▲] and [▼] to select MODE.
    b. Press [ENTER] to change the mode to GRAPH MATCH.
    c. Select START, and then press [ENTER] to display the first distance *vs.* time graph to be matched. The DATMATCH program randomly generates matching graphs like the one shown here. Your graph may be different.

9. Match the first distance *vs.* time graph.

    a. Examine the graph and plan what you will do to match it. Note: The vertical axis runs from 0 to 3 meters. Data will be collected for ten seconds.
    b. Take your starting position in front of the Motion Detector.
    c. Signal your partner to press [ENTER].
    d. Move according to your plan.
    e. Examine the graph of the results.
    f. Sketch your results on Graph 1 below. Describe what you had to do to match the first graph. Sketch the graph you were matching and the graph of your motion.
    g. Press [ENTER], and then choose SAME MATCH from the OPTIONS menu if you want to repeat the first match. If you are ready to move on to a second graph, choose NEW MATCH.
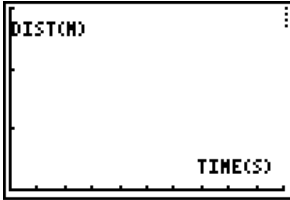
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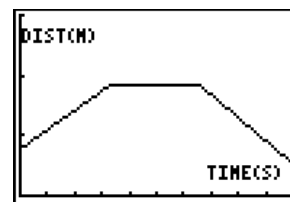
10. Repeat Step 9 until you have matched a total of three distance *vs.* time graphs.

PROCESSING THE DATA (Part II)
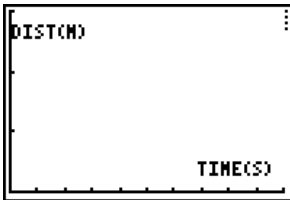
2. Sketch your results in the empty graphs provided below. Describe what you had to do to match each of the graphs.
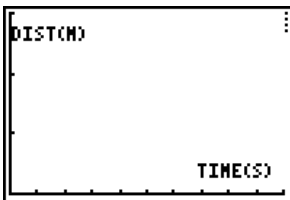
Graph   What I did to match my graph:

DIST(M)

TIME(S)

Graph 1

DIST(M)

TIME(S)

Graph 2

DIST(M)

TIME(S)

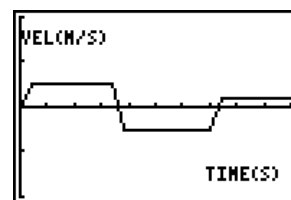*Graph 3*

Part III Velocity *vs*. Time Graphs

11. Set up the calculator and interface for velocity *vs*. time graphing.

   a. Press ENTER, and then choose RETURN TO MAIN from the OPTIONS menu to return to the main screen.
   b. Use ▲ and ▼ to select MODE.
   c. Press ENTER to change the mode to TIME GRAPH.
   d. Use ▲ and ▼ to select DISPLAY.
   e. Press ENTER to change the display to NON LIVE.

12. Explore making velocity *vs*. time graphs.

   a. Take a starting position at the 1-m mark in front of the Motion Detector.
   b. Signal your partner to select START.
   c. Stand still for one second, and then walk to the 3-m mark (away from the Motion Detector) at constant velocity.
   d. Stand still for one second, then walk backwards to the 1-m mark (toward the Motion Detector) at constant velocity.
   e. When data collection ends, ▲ and ▼ to select VELOCITY from the SELECT GRAPH menu.
   f. Sketch your velocity *vs*. time graph below.

PROCESSING THE DATA (Part III)

3. How does this velocity *vs*. time graph differ from your distance *vs*. time graphs made in Steps 6 and 7?
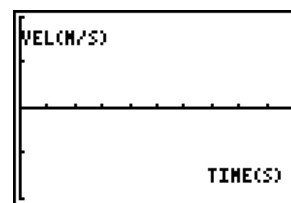
Part IV Matching Velocity *vs*. Time Graphs

13. Set up the calculator and interface for velocity *vs*. time graph matching.

   a. Press ENTER, and then choose RETURN TO MAIN SCREEN from the SELECT GRAPH menu to return to the main screen.
   b. Use ▲ and ▼ to select MODE.
   c. Press ENTER to change the mode to GRAPH MATCH.
   d. Use ▲ and ▼ to select DISPLAY.
   e. Press ENTER to change the display to VELOCITY.
   f. Select START, and then press ENTER to display the first velocity *vs*. time graph to be matched. The DATMATCH program randomly generates matching graphs like the one shown here. Your graph may be different.

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14. Match the first velocity *vs.* time graph.

   a. Examine the graph and plan what you will do to match it. Data will be collected for ten seconds.
   b. Take your starting position in front of the Motion Detector.
   c. Signal your partner to press ENTER.
   d. Move according to your plan.
   e. Examine the graph of the results.
   f. Sketch your results on Graph 1 below. Describe what you had to do to match the first graph. Show the graph you were matching and the graph of your motion.
   g. Press ENTER, and then choose SAME MATCH from the OPTIONS menu if you want to repeat the first match. If you are ready to move on to a second graph, choose NEW MATCH.

15. Repeat Step 14 for a second velocity vs. time graph.

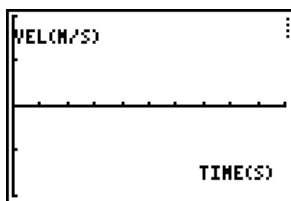## PROCESSING THE DATA (Part IV)

4. Sketch your results in the empty graphs provided below. Describe what you had to do to match each of the graphs.

   Graph   What I did to match my graph:
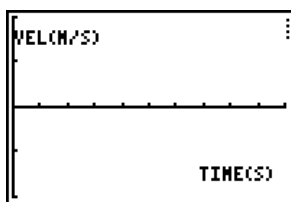
Graph 1

Graph 2

EXTENSIONS

1. Create a graph-making challenge. Sketch a distance *vs.* time graph on a piece of paper and challenge another student in the class to match your graph. Have the other student challenge you in the same way.

2. Create a velocity *vs.* time challenge in a similar manner.

TEACHER INFORMATION

Graphing Your Motion

1. This activity requires the DatMatch program rather than the DataMate program used by most LabPro and CBL 2 activities. The DatMatch program can be found on the CD that comes with this book. The DatMatch program must be loaded to the calculator from a computer using a TI-Graph Link cable and TI-Graph Link software. Instructions for this process are in Appendix B under the section *Transferring the DatMatch Program to a Calculator*.

2. This experiment may be the first time your students use the Motion Detector. A little coaching on its use now will save time later in the year as the Motion Detector is used in many experiments. Here are some hints for effective use of the Motion Detector.

   - In using the Motion Detector, it is important to realize that the ultra sound is emitted in a cone about 30° wide. Anything within the cone of ultrasound can cause a reflection and possibly an accidental measurement. A common problem in using Motion Detectors is getting unintentional reflections from a desk or chair in the room.
   - Often unintended reflections can be minimized by tilting the Motion Detector slightly.
   - If you begin with a velocity or acceleration graph and obtain a confusing display, switch back to a distance graph to see if it makes sense. If not, the Motion Detector may not be properly targeting the target.
   - The Motion Detector does not properly detect objects closer than 0.4 m. The maximum range is about 6 m, but stray objects in the wide detection cone can be problematic at this distance.
   - Sometimes a target may not supply a strong reflection of the ultrasound. For example, if the target is a person wearing a bulky sweater, the resulting graph may be inconsistent.
   - If the velocity and acceleration graphs are noisy, try to increase the strength of the ultrasonic reflection from the target by increasing the target's area.

3. You may want to have your students hold a large book in front of them as they walk in front of the Motion Detector. This will produce better graphs because it smoothes out the motion.

4. If you are using an old Motion Detector with a non-detachable cable, the interface will not be able to identify it. Instead, set up DataMate for the Motion Detector manually. To do this,

   a. Select SETUP from the main screen.
   b. Use the cursor keys ▼ and ▲ to select DIG (CBL 2) or DIG 1 (LabPro).
   c. Press ENTER.
   d. Choose MOTION from the SELECT SENSOR list.
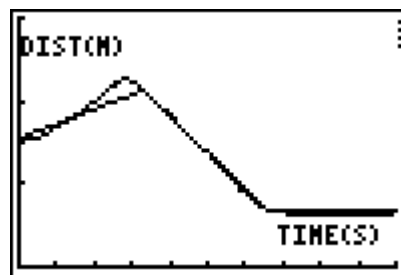   e. Select OK to return to the main screen.

ACKNOWLEDGMENT

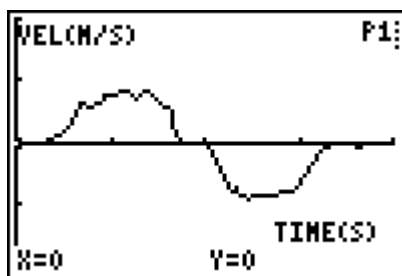We wish to thank Rick Sorensen for his help in developing this experiment.
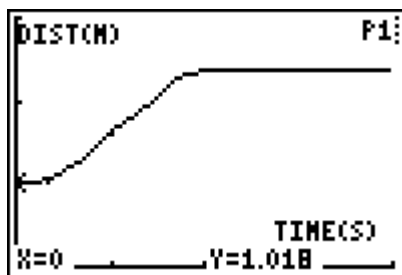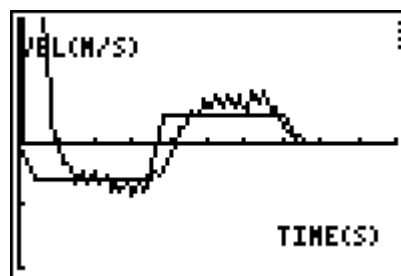
SAMPLE RESULTS

Distance vs. Time

Matching Distance vs. Time

Velocity vs. Time

Matching Velocity vs. Time

ANSWERS TO QUESTIONS

1. The slope of the portion of the graph corresponding to movement is greater for the faster trial.

2. See the Sample Results.

3. A velocity *vs.* time graph can have points below the x-axis. Distance *vs.* time matching graphs are generally smoother than velocity *vs.* time matching graphs.

4. See the Sample Results.

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