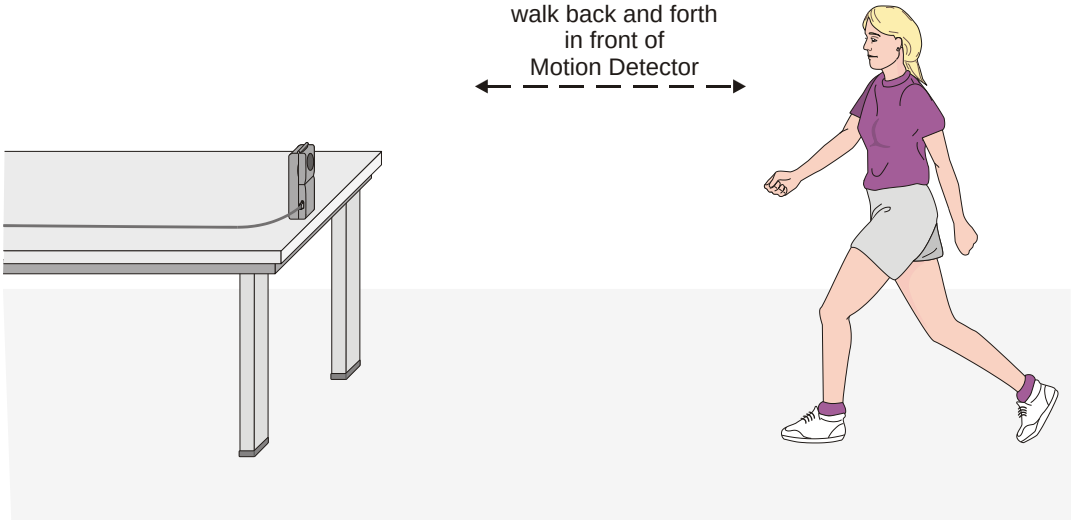
MATCH THIS MOTION

One of the most effective methods of describing motion is to plot graphs of distance, velocity, and acceleration *vs*. time. From such a graphical representation, it is possible to determine in what direction an object is going, how fast it is moving, how far it traveled, and whether it is speeding up or slowing down. In this experiment, you will use a Motion Detector to plot real time graphs of *your* motion as you move across the classroom.

The Motion Detector measures the time it takes for a high frequency sound pulse to travel from the detector to an object and back. Using this round-trip time and the speed of sound, you can determine the distance to the object; that is, its position. Logger *Pro* will perform this calculation for you. It can then use the change in position to calculate the object's velocity and acceleration. All of this information can be displayed either as a table or a graph. A qualitative analysis of the graphs of your motion will help you develop an understanding of the concepts of kinematics.



PROCEDURE

Part I: Preliminary Experiments – work in groups of 3-4

1. Connect the Motion Detector to DIG/SONIC 2 of the LabPro. (Note that the second input is used!)

2. Place the Motion Detector so that it points toward an open space at least 4 m long. 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. You may need to move tables.

3. From the File menu, open the Experiment folder called *Physics with Vernier*. Then open the experiment file *01a Graph Matching*. One graph will appear on the screen. The vertical axis has distance scaled from 0 to 5 meters. The horizontal axis has time scaled from 0 to 10 seconds.

4. Using Logger *Pro*, produce a graph of your motion when you walk away from the detector with constant velocity. To do this, stand about 1 m from the Motion Detector and have your lab partner click Collect. Walk slowly away from the Motion Detector when you hear it begin to click. **In your notes, sketch what the distance *vs*. time graph looks like on your computer.**

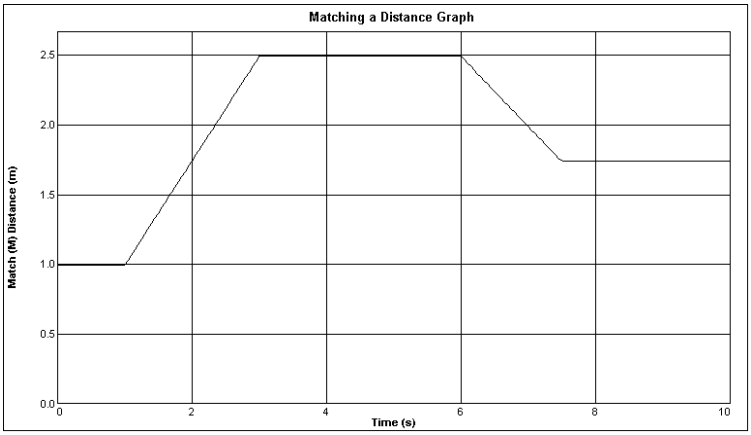
If your motion sensor does not appear to be working, try the following:

- Reposition the detector so that it is not near any vertical flat surfaces (that sound waves might be bouncing off).
- Make sure it is not picking up the motion of another group.
- Relocate the detector on a lab stool, a chair, or at the edge of a table.
- If the detector is not clicking, replace it with another detector and give the non-working one to your teacher.
- It may not measure you for all four meters – if not, try repositioning the detector, but it might be that you have reached the limit of the detector as well.
- Hold a notebook while moving to provide a flat surface for the detector to bounce sound waves on.

5. **On the same graph, sketch your prediction of what the distance vs. time graph will look like if you walk faster.** Check your prediction with the Motion Detector to see if you were correct.

Part II: Distance *vs.* Time Graph Matching – work in groups of 3-4

6. Open the experiment file *01b Graph Matching*. The distance vs. time graph shown will appear.



7. **In your notes, make a detailed prediction of how you think you would walk to produce this target graph.** Include information about where you will be at various times, how long you will be there, and how quickly you will move from place to place.

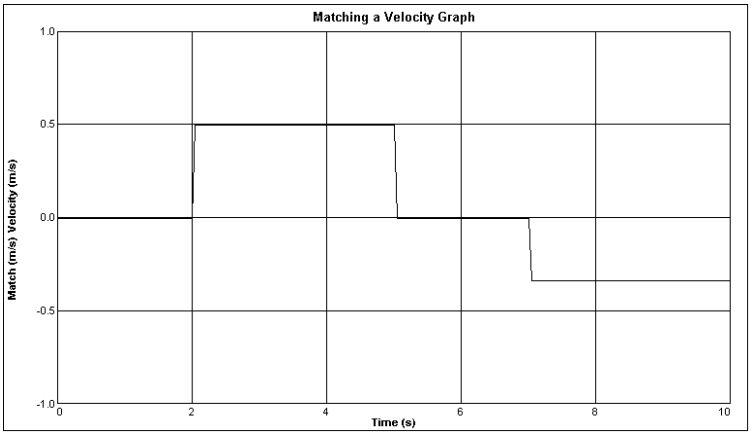
8. To test your prediction, choose a starting position and stand at that point. Start data collection by clicking Collect. When you hear the Motion Detector begin to click, walk in such a way that the graph of your motion matches the target graph on the computer screen. If you were not successful, repeat the process until your motion closely matches the graph on the screen. **In your notes, discuss whether your prediction from question 8 matched how you actually needed to move to match the graph on the screen.**

9. In your group, discuss:
   - What does the slope of a distance vs. time graph tells you about how something is moving?
   - What are the difference between a positive, negative, and zero slope?
   - What does it mean when the slope is changing (i.e., when the line on the graph is curved)?
   - What information does the coordinates of a point tell you?

   Test your ideas by using the Motion Detector. **In your notes, summarize your discussion and your observations.**

Part III: Velocity *vs.* Time Graph Matching

10. Open the experiment file *01d Graph Matching*. You will see the following velocity vs. time graph.



11. **In your notes, make a detailed prediction of how you think you would walk to produce this target graph.** Include information about where you will be at various times, how long you will be there, and how quickly you will move from place to place.

12. To test your prediction, choose a starting position and stand at that point. Start Logger *Pro* by clicking Collect. When you hear the Motion Detector begin to click, walk in such a way that the graph of your motion matches the target graph on the screen. It will be more difficult to match the velocity graph than it was for the distance graph. **In your notes, discuss whether your prediction from question 8 matched how you actually needed to move to match the graph on the screen.**

13. Once you have a fairly close match to this graph, **in your notes, sketch your prediction what the distance *vs.* time graph would look like.**

14. To check your prediction, click on the word "Velocity" on the vertical axis and change the graph so that it displays your position data instead of your velocity data. **In your notes, compare your prediction with what you see on the graph**. You'll have to remember here that since the data just reflects your best attempt to match the graph, it won't be a perfect match to an ideal prediction. **In your notes, use a different color of pencil or pen to correct your predicted distance vs. time graph**.

15. In your group, discuss
    - What does the slope of a velocity vs. time graph tells you about how something is moving?
    - What are the difference between a positive, negative, and zero slope, and what do these slopes tell you about how something's speed and position are changing?
    - What information does the coordinates of a point on a velocity vs. time graph tell you?

    Test your ideas by using the Motion Detector. **In your notes, summarize your discussion and your observations.**

16. With your group, discuss what the *area* between the graph and the time axis represents on a velocity vs. time graph. You may need to do some additional research online or in your textbook. **In your notes, summarize your discussion.**

17. You will be asked to interpret the slope, coordinates, and other features of distance and velocity vs. time graphs on a test (including the area between the graph and the axis of a velocity vs. time graph). If you have extra time with the equipment, take advantage of it by challenging yourself to understand these graphs as clearly as you possibly can.