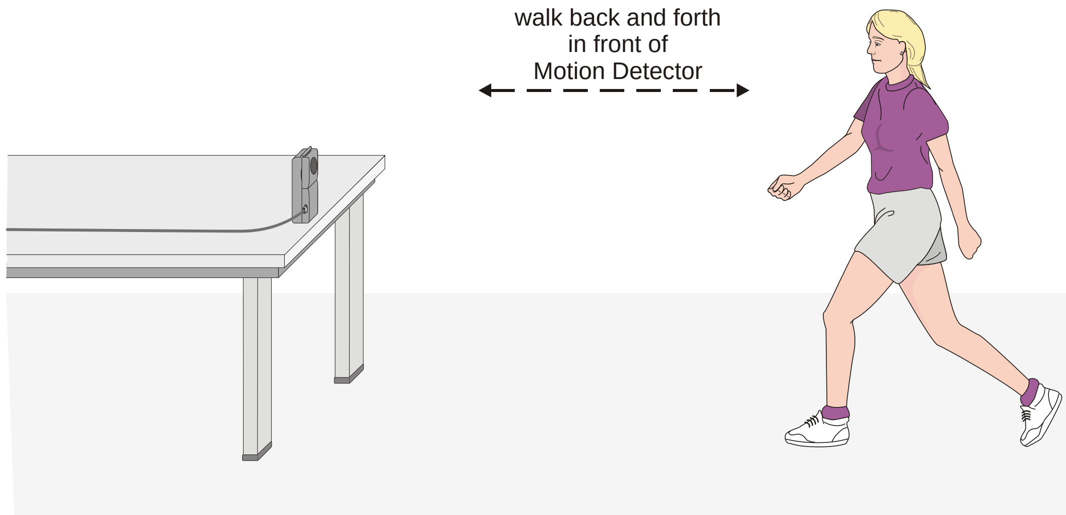
MATCH THIS MOTION

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.



OBJECTIVES

- Analyze the motion of a student walking across the room.
- Predict, sketch, and test distance *vs*. time kinematics graphs.
- Predict, sketch, and test velocity *vs*. time kinematics graphs.

INSTRUCTIONS

- **Follow the procedure. Your write-up (one per group) should include all items that have (WU) within the procedure step.**

MATERIALS

Compter with Logger Pro Software	Vernier Motion Detector
LabPro or Universal Lab Interface	meter stick
	masking tape

PRELIMINARY QUESTIONS

1. Use a coordinate system where time is on the x-axis and the other variable (*d*, *v*, *a*) is on the y-axis. Sketch the distance *vs*. time graph for each of the following situations **(WU)**:
   - An object at rest
   - An object moving in the positive direction with a constant speed
   - An object moving in the negative direction with a constant speed
   - An object that is accelerating in the positive direction, starting from rest
2. Sketch the velocity *vs*. time graph for each of the situations described above. **(WU)**

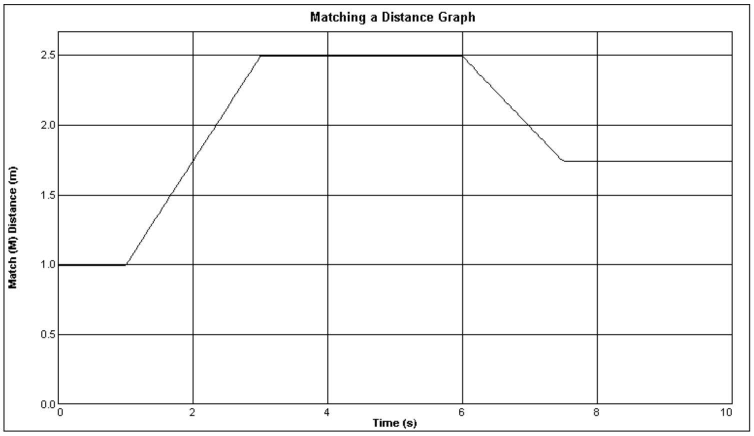
PROCEDURE

Part I: Preliminary Experiments

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. Sketch what the distance *vs*. time graph looks like on your computer. **(WU) 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 Mr. K.**
   - **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 what the distance *vs.* time graph will look like if you walk faster. Check your prediction with the Motion Detector and indicate if you were correct. **(WU)**
6. Try to match the shape of the distance *vs*. time graphs that you sketched in the Preliminary Questions section by walking in front of the Motion Detector.

Part II: Distance *vs*. Time Graph Matching

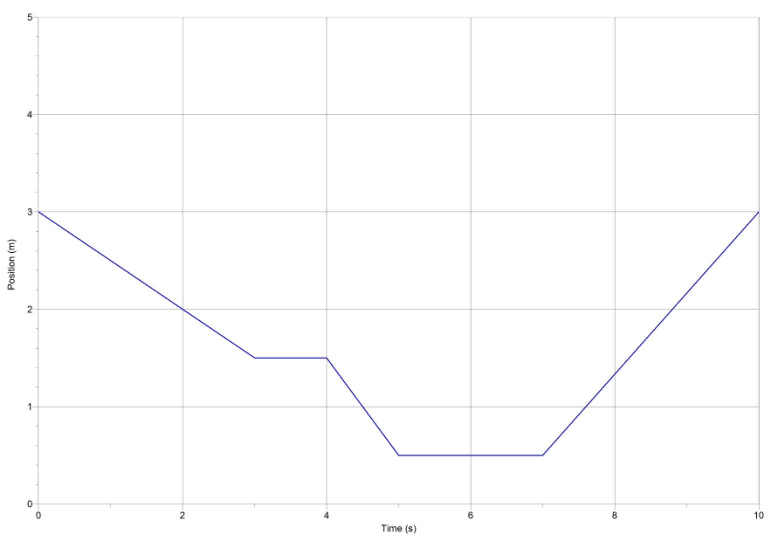
7. Open the experiment file *01b Graph Matching*. The distance *vs*. time graph shown will appear.



8. Describe how you would walk to produce this target graph. **(WU)**

9. 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. Sketch the graph with your best attempt. **(WU)**

10. Open the experiment file *01c Graph Matching* and repeat Steps 8 & 9, using the new target graph.



11. Describe how you walked for each of the graphs that you matched (if different from your predictions). **(WU)**

12. Explain the significance of the slope of a distance *vs*. time graph. Include a discussion of positive and negative slope. **(WU)**

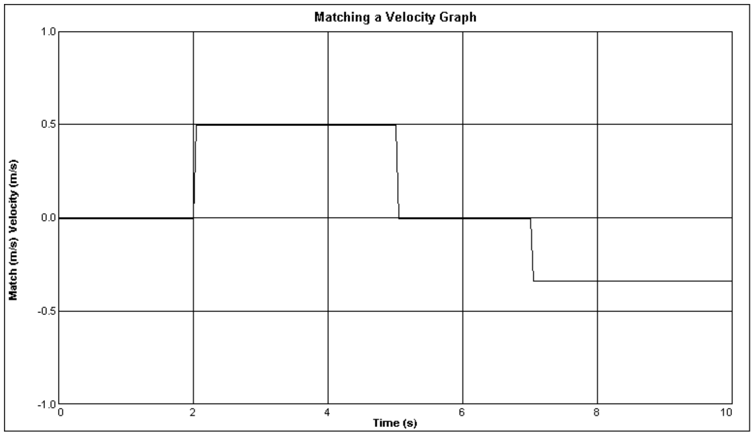
13. What type of motion is occurring when the slope of a distance *vs*. time graph is zero? **(WU)**

14. What type of motion is occurring when the slope of a distance *vs*. time graph is constant? **(WU)**

15. What type of motion is occurring when the slope of a distance *vs*. time graph is changing? Test your answer to this question using the Motion Detector. **(WU)**

Part III: Velocity *vs*. Time Graph Matching

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



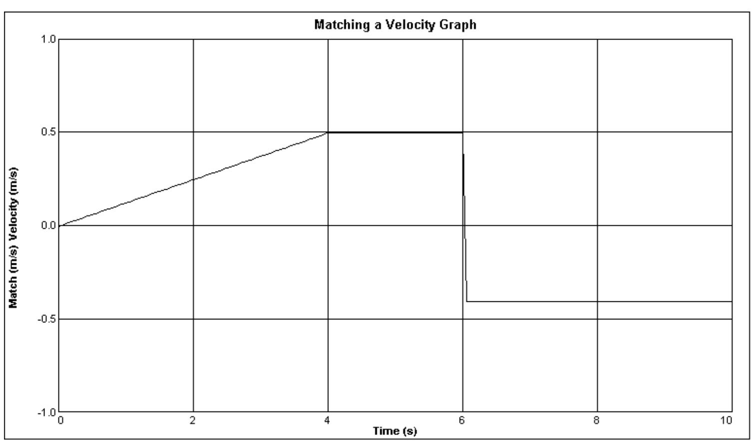
17. Describe how you would walk to produce this target graph. **(WU)**

18. 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.

19. Once you have a fairly close match to this graph, try to predict what the distance *vs*. time graph would look like. **(WU)**

20. 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. 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 a different color pencil, correct your prediction from #19 by making inferences from your displayed position data. **(WU)**

21. Open the experiment file *01e Graph Matching*. Repeat Steps 17 -- 20 for this graph. **(WU)**



22. Open the experiment file *01g Graph Matching*. Repeat Steps 17 -- 20 for this graph. **(WU).**

23. What does the area between the graph and the time axis represent on a velocity vs. time graph? You may need to consult one of your assigned readings from your textbook. Verify your answer by using a motion sensor. (**WU**)

24. What type of motion is occurring when the slope of a velocity *vs*. time graph is zero? **(WU)**

25. What type of motion is occurring when the slope of a velocity *vs*. time graph is not zero? Consider both positive and negative slopes. Test your answer using the Motion Detector. **(WU)**

26. Why don’t the last three velocity *vs*. time graphs have any portions of the curve that are completely vertical? Is it possible for an object to move so that it produces an absolutely vertical line on a velocity *vs*. time graph? Explain. **(WU)**

27. Remove the masking tape strips from the floor.