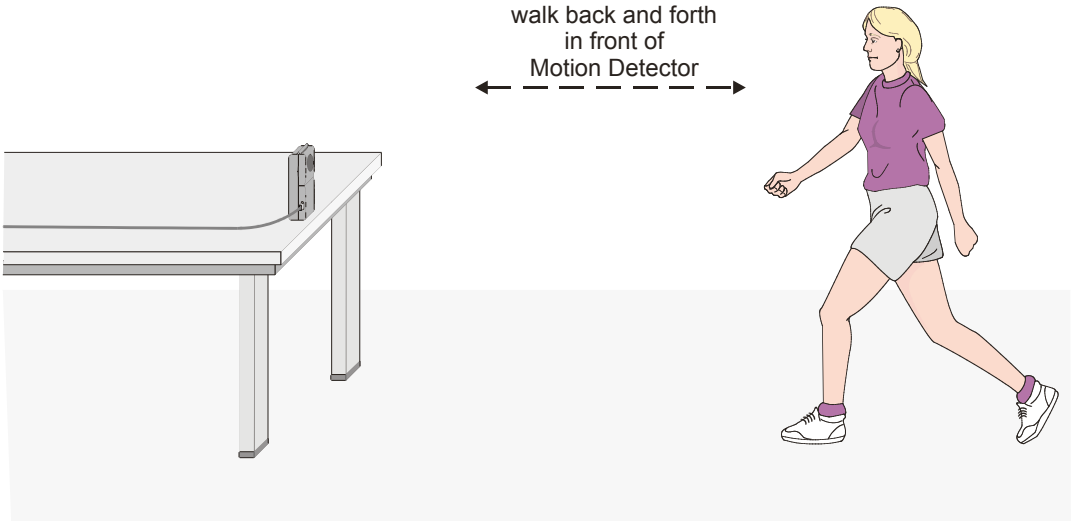
Graph Matching

One of the most effective methods of describing motion is to plot graphs of position, 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 determine this information by plotting a real time graph 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 position of the object. 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 position *vs*. time kinematics graphs.
- Predict, sketch, and test velocity *vs*. time kinematics graphs.

MATERIALS

computer
Vernier computer interface (LabPro)
Logger *Pro*
Vernier Motion Detector
meter stick
masking tape

PRELIMINARY QUESTIONS

1. Use a coordinate system with the origin at far left and positive positions increasing to the right. Sketch the position *vs*. time graph for each of the following situations:
   a. An object at rest
   b. An object moving in the positive direction (away from the origin) with a constant speed
   c. An object moving in the negative direction (towards the origin) with a constant speed
   d. 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.

PROCEDURE

Part I Preliminary Experiments

1. Connect the Motion Detector to the DIG/SONIC 1 channel of the interface. If the Motion Detector has a sensitivity switch, set it to Normal.
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 positions from the Motion Detector.
3. Open the file "01a Graph Matching" from the *Physics with Vernier* folder.
4. Using Logger *Pro*, produce a position *vs.* time and velocity *vs* time graph of your motion when you walk away from the detector with a slow 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.
5. Sketch what the graphs will look like if you walk faster. Check your prediction with the Motion Detector.
6. Test your predictions in the Preliminary Questions section by walking in front of the Motion Detector. If your predictions of graph shapes were incorrect, draw the correct shape over your prediction in a different color.

Part II Position *vs*. Time Graph Matching

7. Open the experiment file "01b Graph Matching." A position *vs*. time graph will appear.
8. Describe how you would walk to produce this target graph.
9. To test your prediction, choose a starting position and stand at that point. Have your partner 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.
10. If you were not successful, repeat the process until your motion closely matches the graph on the screen. Print the graph with your best attempt.
11. Open the experiment file "01c Graph Matching" and repeat Steps 8–10, using a new target graph.
12. Answer the Analysis questions for Part II before proceeding to Part III.

Part III Velocity *vs.* Time Graph Matching

13. Open the experiment file "01d Graph Matching." A velocity *vs*. time graph will appear.
14. Describe how you would walk to produce this target graph.
15. To test your prediction, choose a starting position and stand at that point. Have your partner start 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 position graph. If you were not successful, repeat the process until your motion closely matches the graph on the screen. Print the graph with your best attempt.
16. If you were not successful, repeat the process until your motion closely matches the graph on the screen. Print the graph with your best attempt.
17. Open the experiment file "01e Graph Matching." Repeat Steps 14–15 to match this graph. Remove the masking tape strips from the floor.

ANALYSIS (answer on a separate sheet of paper)

Part II Position *vs.* Time Graph Matching

1. Describe how you walked for each of the graphs that you matched.
2. Explain the significance of the slope of a position *vs*. time graph. Include a discussion of positive and negative slope.
3. What type of motion is occurring when the slope of a position *vs*. time graph is zero?
4. What type of motion is occurring when the slope of a position *vs*. time graph is constant?
5. What type of motion is occurring when the slope of a position *vs*. time graph is changing? Test your answer to this question using the Motion Detector.
6. Return to the procedure and complete Part III.

Part III Velocity *vs.* Time Graph Matching

7. Describe how you walked for each of the graphs that you matched.
8. What type of motion is occurring when the slope of a velocity *vs*. time graph is zero?
9. What type of motion is occurring when the slope of a velocity *vs*. time graph is not zero? Test your answer using the Motion Detector.

EXTENSIONS

1. Create a graph-matching challenge. Sketch a position *vs*. time graph using the prediction feature of Logger *Pro*: Choose Draw Prediction from the Analyze menu, and use the mouse to draw a new target graph. 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.

3. Create a position *vs.* time graph by walking in front of the Motion Detector. Store the graph by choosing Store Latest Run from the Experiment menu. Have another student match your run.

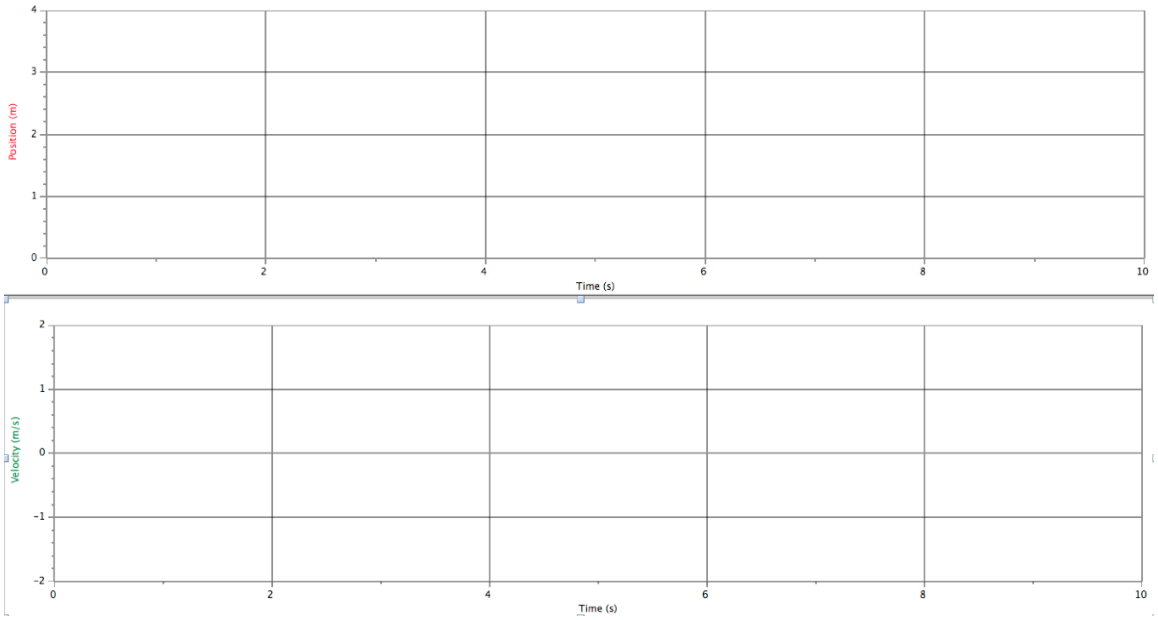
4. Create a velocity *vs.* time graph by walking in front of the Motion Detector. Store the graph by choosing Store Latest Run from the Experiment menu. Have another student match your run.

5. Use the automatic graph-match feature of Logger *Pro* to generate additional exercises. Open the experiment file "01f Graph Matching" for position matches and "01g Graph Matching" for velocity matches. Click the Generate Graph Match button in the toolbar to get a new match exercise.

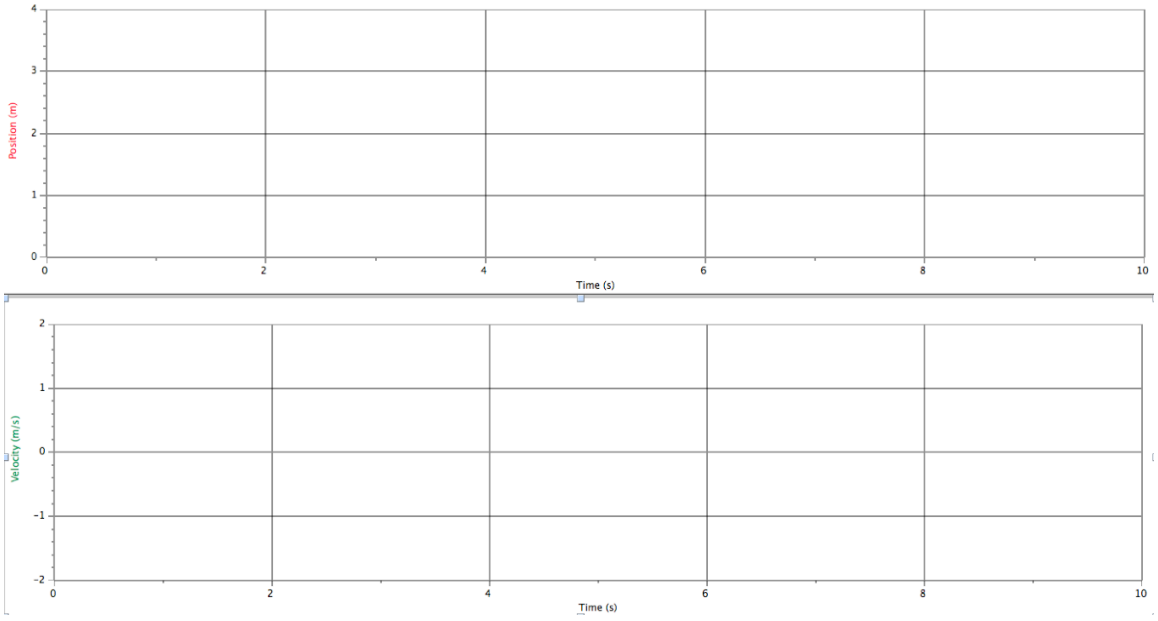
Graph Matching (LabPro & Computer) Data Sheet

Prelinimary Questions

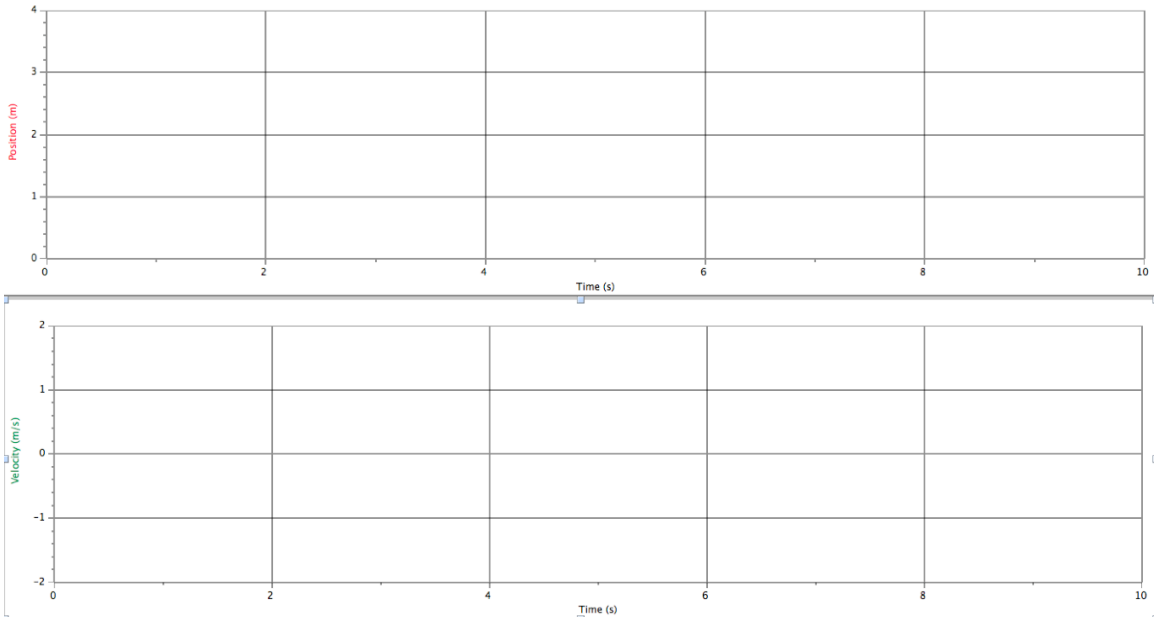
a. Sketch the graphs for an object at rest



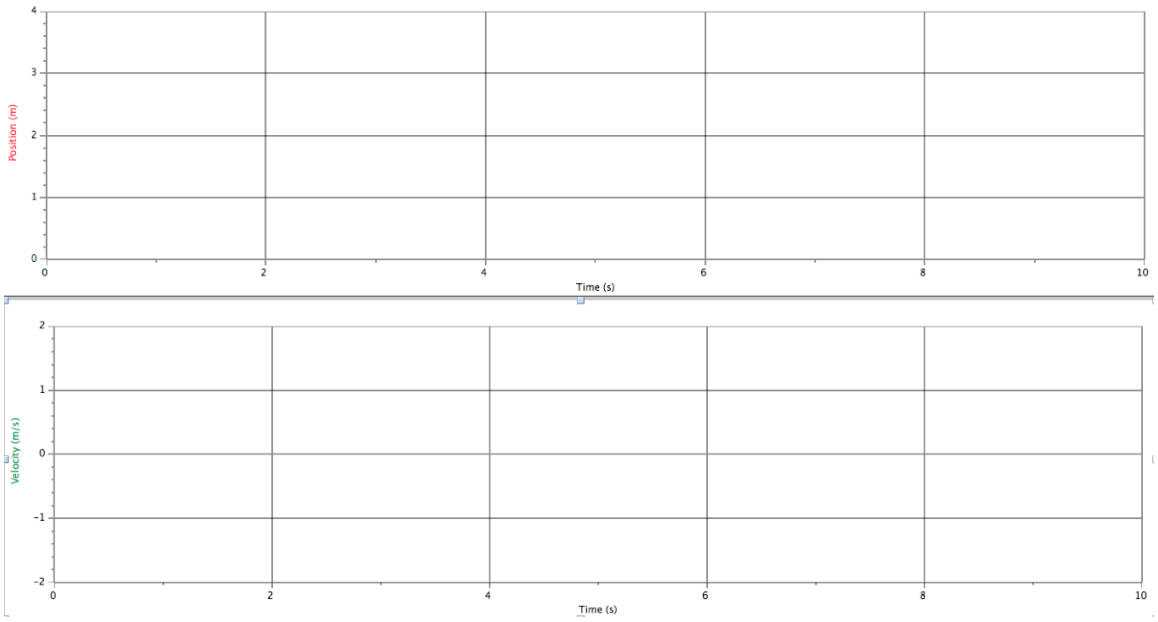
b. Sketch the graphs for an object moving in the positive direction (away from the origin) with a constant speed



c. Sketch the graphs for an object moving in the negative direction (towards the origin) with a constant speed

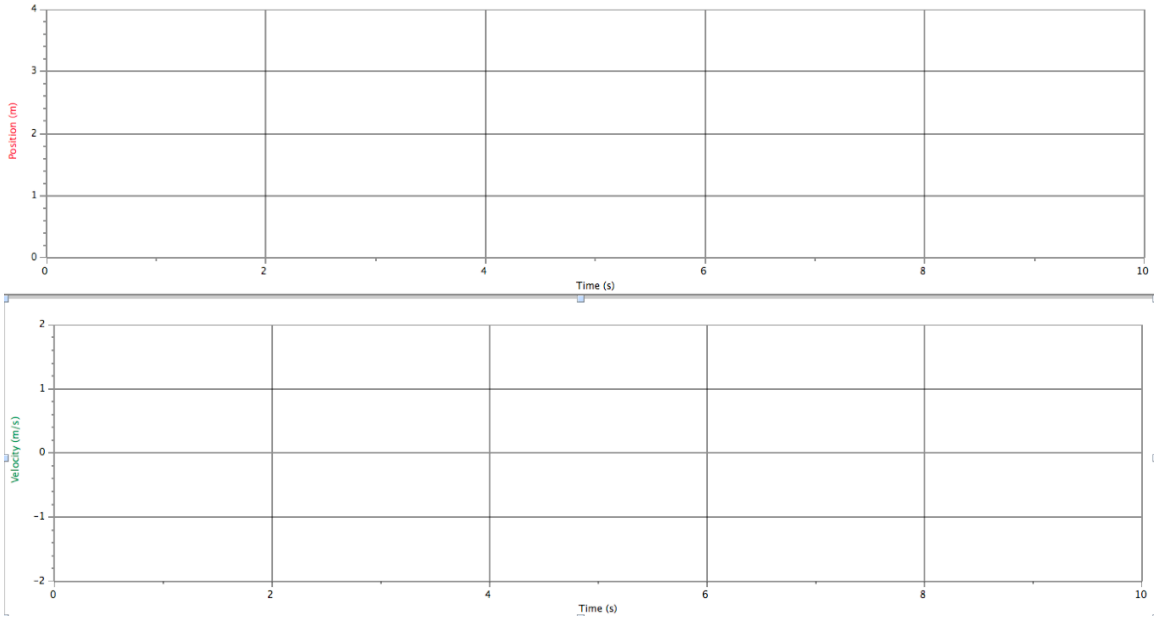


d. Sketch the graphs for an object that is accelerating in the positive direction, starting from rest



Part I Preliminary Experiments

Sketch position *vs* time and velocity *vs* time graphs of walking away from the wall with a slow constant velocity in one color and a fast constant velocity in another color.



Part II Position *vs*. Time Graph Matching

Position Match 1. Write down your prediction of how you would walk to reproduce the target graph in *01b Graph Matching.*

Position Match 2. Write down your prediction of how you would walk to reproduce the target graph in *01c Graph Matching.*

Part III Velocity *vs*. Time Graph Matching

Velocity Match 1. Write down your prediction of how you would walk to reproduce the target graph in *01d Graph Matching.*

Velocity Match 2. Write down your prediction of how you would walk to reproduce the target graph in *01e Graph Matching.*