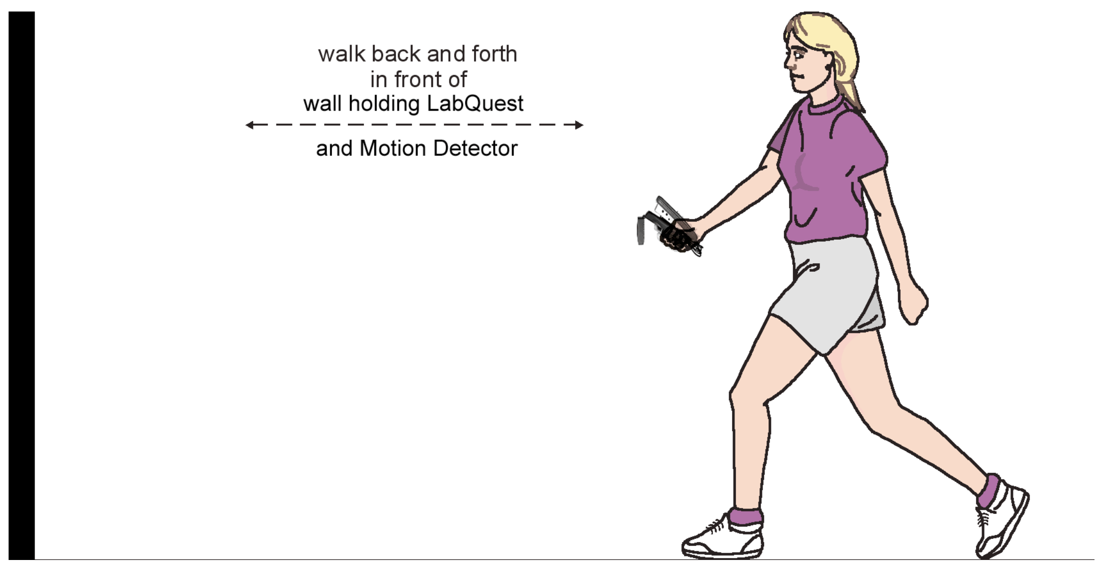
LabQuest

1

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, the interface can determine the distance to the object; that is, its position. It can then use the change in position to calculate the object's velocity and acceleration. All of this information can be displayed in a graph. A qualitative analysis of the graphs of your motion will help you understand 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

LabQuest	meter stick
LabQuest App	masking tape
Motion Detector	

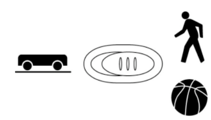
PRELIMINARY QUESTIONS

1. Sketch the position *vs*. time graph for each of the following situations. Use a coordinate system with the origin at far left and positive distances increasing to the right.
   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

1. Find an open area at least 4 m long in front of a wall. Use short strips of masking tape on the floor to mark distances of 1 m, 2 m, and 3 m from the wall. You will be measuring distances from the Motion Detector in your hands to the wall.

2. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to DIG 1 of LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.



3. On the Meter screen, tap Length, then change the data-collection length to 10 seconds. Select OK.

Part I Preliminary Experiments

4. Open the hinge on the Motion Detector. When you collect data, hold the Motion Detector so the round, metal detector is always pointed directly at the wall. Sometimes you will have to walk backwards.

5. Monitor the position readings. Move back and forth and confirm that the values make sense.

6. Make a position *vs* time and velocity *vs* time graph of your motion when you walk away from the wall with a slow constant velocity. To do this, stand about 1 m from the wall and start data collection. Walk backward, slowly away from the wall after data collection begins. Record your graphs on your data sheet.

7. Sketch what the graphs will look like if you walk faster. Check your prediction with the Motion Detector. Start data collection when you are ready to begin walking. Record your graphs on your data sheet.

6. Test your predictions in the Preliminary Questions section by walking in back and forth in front of the wall. 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. Choose Motion Match ► New Position Match from the Analyze menu to set up LabQuest for graph matching. A target graph will be displayed for you to match.

8. Write down how you would walk to reproduce the target graph. Sketch a copy of the graph.

9. To test your prediction, choose a starting position. Start data collection, then walk in such a way that the graph of your motion matches the target graph on the screen.
10. If you were not successful, start data collection again when you are ready to begin walking. Repeat this process until your motion closely matches the graph on the screen. Sketch the graph with your best attempt.
11. Perform a second graph match by again choosing Motion Match ► New Position Match from the Analyze menu. This will generate a new target graph for you to match.
12. Answer the Analysis questions for Part II before proceeding to Part III.

Part III Velocity vs. Time Graph Matching

13. LabQuest can also generate random target velocity graphs for you to match. Choose Motion Match ► New Velocity Match from the Analyze menu to view a velocity target graph.
14. Write down how you would walk to produce this target graph. Sketch or print a copy of the graph.
15. To test your prediction, choose a starting position and stand at that point. Have your partner start data collection, then 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.
16. If you were not successful, have your partner start data collection when you are ready to start walking. Repeat this process until your motion closely matches the graph on the screen. Print or sketch the graph with your best attempt.
17. Perform a second velocity graph match by choosing Motion Match ► New Velocity Match from the Analyze menu. This will generate a new target velocity graph for you to match.
18. 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

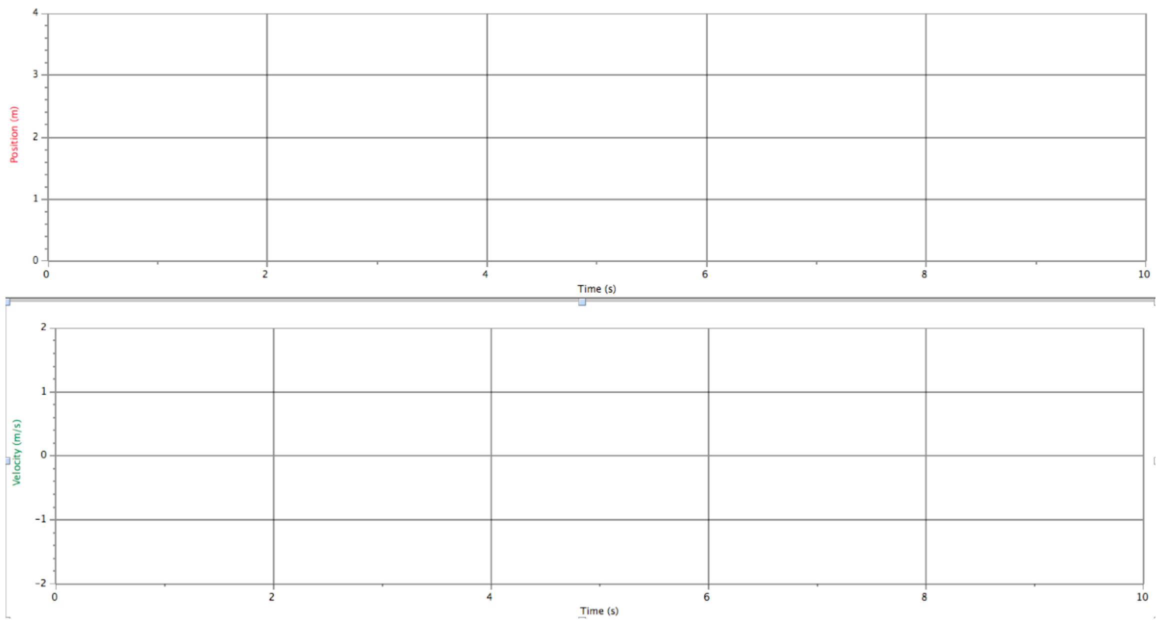
1. Create a graph-matching challenge. Sketch a position *vs*. time graph on a piece of paper and challenge another student in the class to match your graph. Have the other student challenge you in the same way.

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

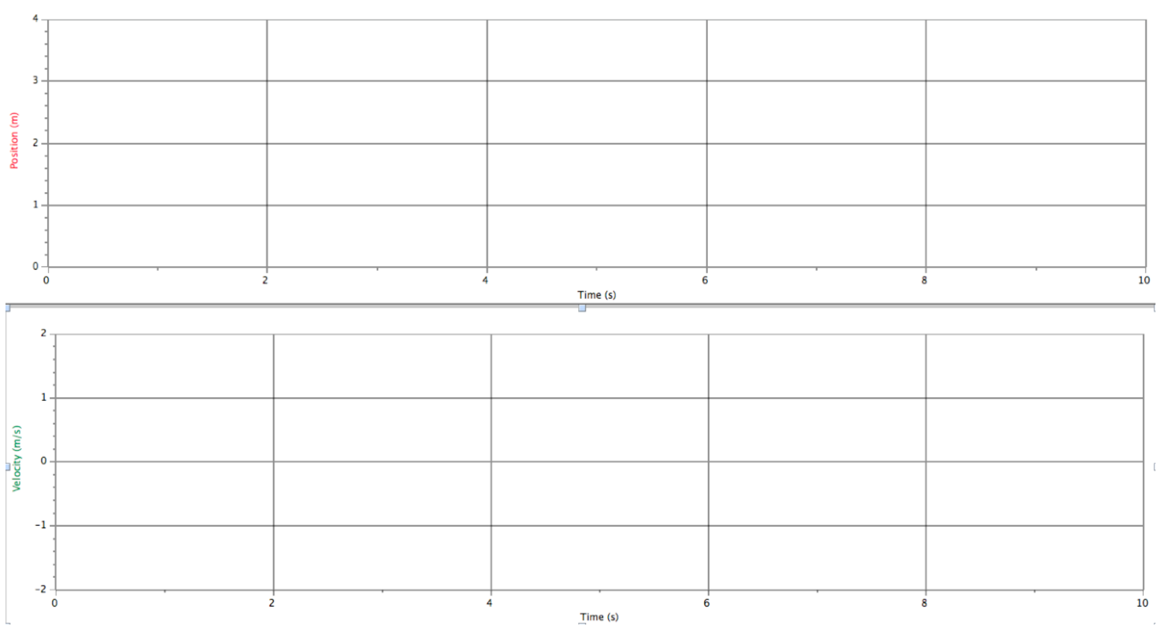
Graph Matching (LabQuest) Data Sheet

Prelinimary Questions

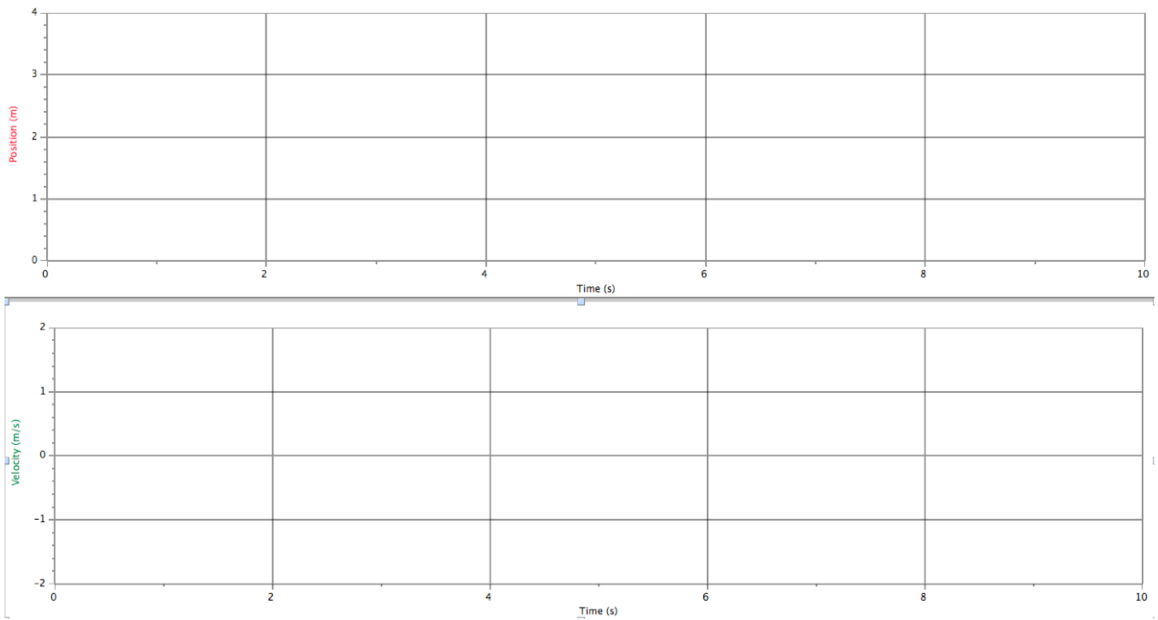
a. Sketch the graphs for an object at rest



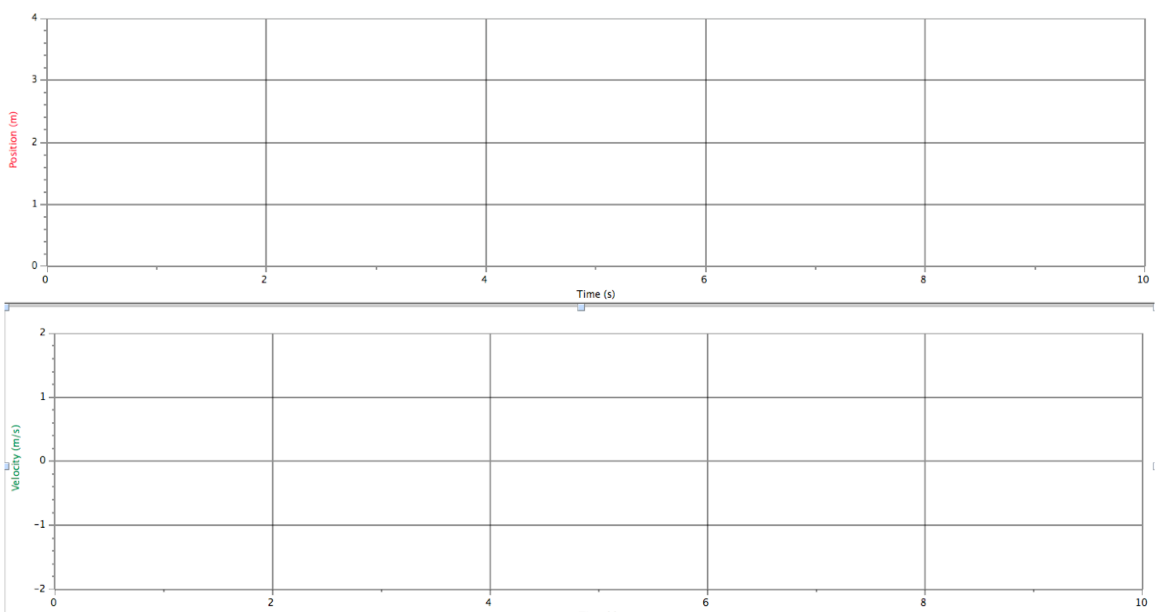
b. Sketch the graphs for an object moving in the positive direction (away from the origin) with a constant speed



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

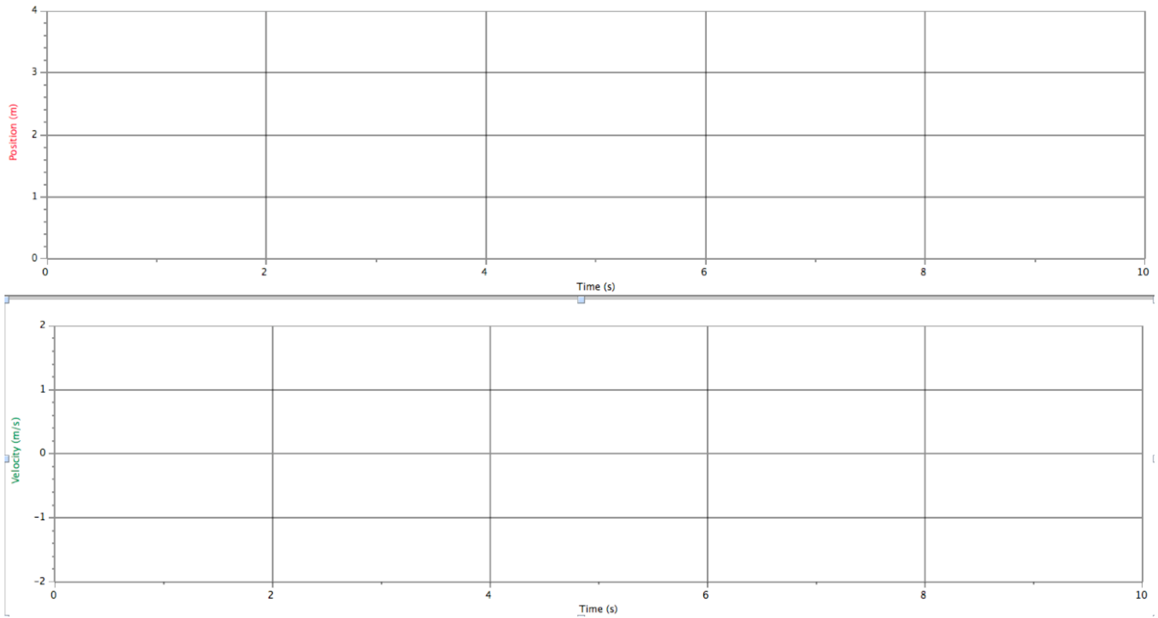


d. Sketch the graphs for an object that is accelerating in the positive direction, starting from rest



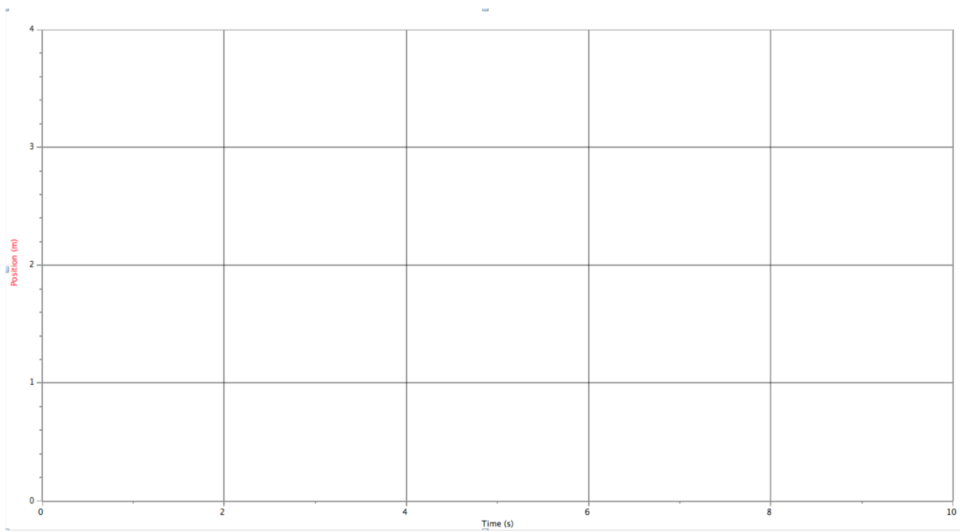
Part I Preliminary Experiments

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.

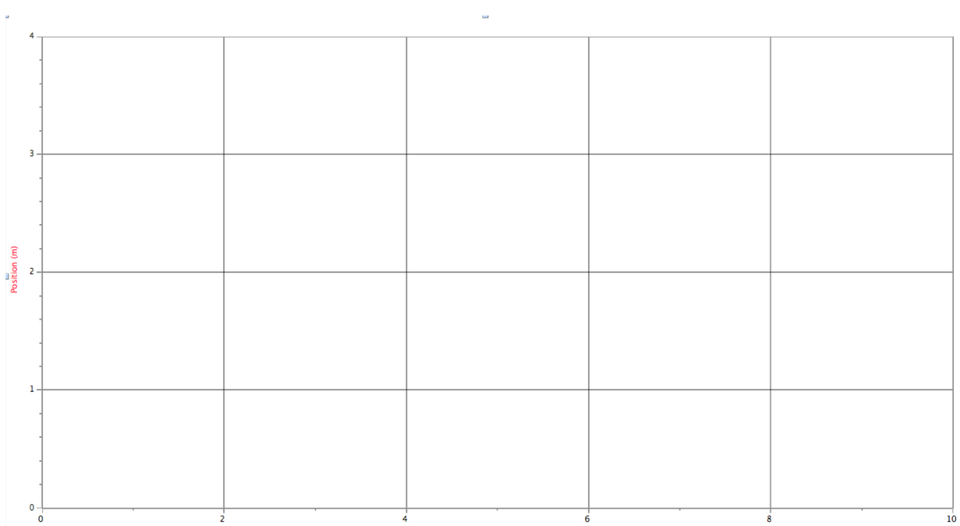


Part II Position *vs*. Time Graph Matching

<u>Position Match 1</u>. Write down your prediction of how you would walk to reproduce the target graph. Sketch a copy of the graph. Sketch your best attempt at matching in a different color.

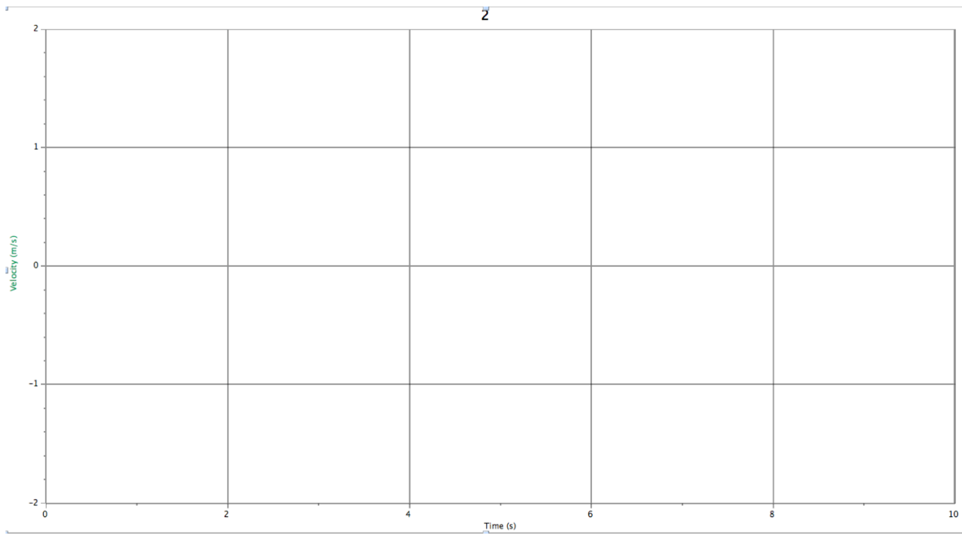


<u>Position Match 2.</u> Write down your prediction of how you would walk to reproduce the target graph. Sketch a copy of the graph. Sketch your best attempt at matching in a different color.



Part III Velocity *vs.* Time Graph Matching

Velocity Match 1. Write down your prediction of how you would walk to reproduce the target graph. Sketch a copy of the graph. Sketch your best attempt at matching in a different color.



Velocity Match 2. Write down your prediction of how you would walk to reproduce the target graph. Sketch a copy of the graph. Sketch your best attempt at matching in a different color.