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 develop an understanding of the concepts of kinematics.

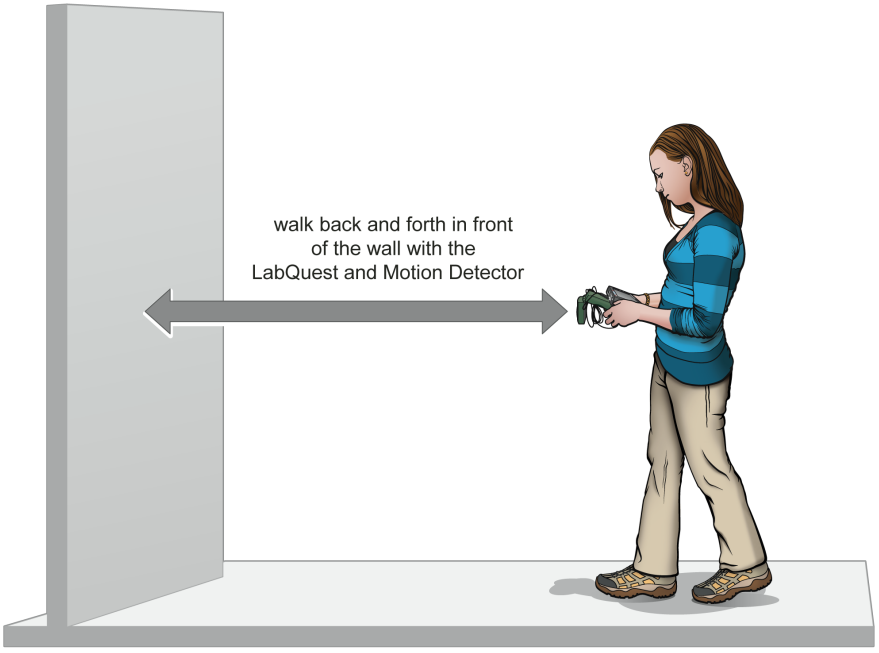


Figure 1

OBJECTIVES

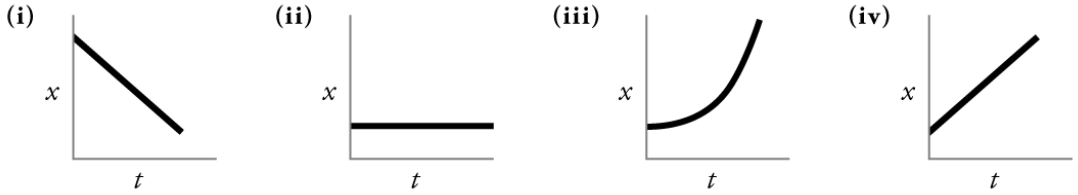
- Analyze the motion of a student walking across the room.
- Predict, sketch, and test position *vs.* time kinematics graphs.
- Predict, sketch, and test velocity *vs.* time kinematics graphs.

MATERIALS

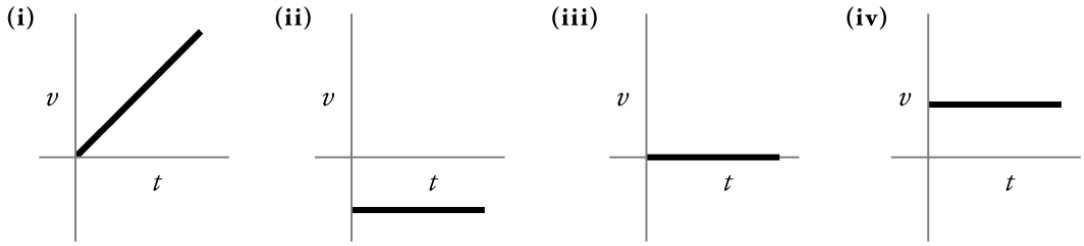
LabQuest
LabQuest App
Vernier Motion Detector
meter stick
masking tape

PRELIMINARY QUESTIONS

1. Below are four position *vs.* time graphs labeled (i) through (iv). Identify which graph corresponds to each of the following situations and explain why you chose that graph.
   a. An object at rest
   b. An object moving in the positive direction with a constant speed
   c. An object moving in the negative direction with a constant speed
   d. An object that is accelerating in the positive direction, starting from rest



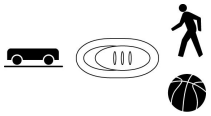
2. Below are four velocity *vs.* time graphs labeled (i) through (iv). Identify which graph corresponds to each of the following situations. Explain why you chose that graph.
   a. An object at rest
   b. An object moving in the positive direction with a constant speed
   c. An object moving in the negative direction with a constant speed
   d. An object that is accelerating in the positive direction, starting from rest



PROCEDURE

Part I Preliminary Experiments

1. Set the Motion Detector sensitivity switch to Ball/Walk. Connect the Motion Detector to the digital (DIG) port of LabQuest and choose New from the File menu.



2. On the Meter screen, tap Duration, then change the data-collection duration to 10 seconds. Select OK.

3. 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.

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, as shown in Figures 1 and 2. Sometimes you will have to walk backwards.

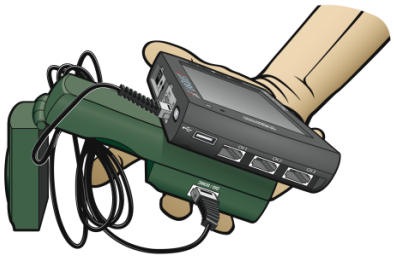


Figure 2

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

6. Make a graph of your motion when you walk away from the wall with constant velocity. To do this, stand about 1 m from the wall and start data collection. Slowly walk backward away from the wall after data collection begins.

7. Examine the graph. Sketch a prediction of what the position *vs.* time graph will look like if you walk faster. Check your prediction with the Motion Detector. Start data collection when you are ready to begin walking.

Part II Position *vs.* Time Graph Matching

8. 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.

9. Describe how you would walk to reproduce the target graph.

10. 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.

11. 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. Print or sketch the graph with your best attempt showing both the target graph and your motion data.

12. 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.

13. Answer the Analysis questions for Part II before proceeding to Part III.

Part III Velocity *vs.* Time Graph Matching

14. 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.

15. Describe how you would walk to produce this target graph. Sketch or print a copy of the graph.

16. To test your prediction, choose a starting position and stand at that point. Start data collection, then walk in such a way that the graph of your motion matches the target graph on the screen. It is more difficult to match the velocity graph than the position graph.

17. If you were not successful, start data collection again 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 showing both the target graph and your motion data.

18. 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.

19. Remove the masking tape from the floor.

20. Proceed to the Analysis questions for Part III.

ANALYSIS

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.

Part III Velocity *vs.* Time Graph Matching

6. Describe how you walked for each of the graphs that you matched.

7. What type of motion is occurring when the slope of a velocity *vs.* time graph is zero?

8. 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-match challenge. Use the Prediction tool in LabQuest to sketch a position *vs.* time graph: Choose Draw Prediction from the Analyze menu, and 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.