Introduction to Linear Motion and Data Acquisition

By

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1. Introduction

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 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 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.

2. Background

Motion is a daily occurrence that one can witness. Though motion maybe easily recognized it is somewhat difficult to describe. Linear motion (or motion in a straight line) is composed of three characteristic ideas. These ideas being, distance, velocity, and acceleration, which are all related. Distance is the length of a straight line that can be drawn between 2 points. Velocity is the rate at which that distance is covered. Finally Acceleration is the rate at which that velocity is covered.

- $dis \tan ce = x$

- $velocity = v = \dfrac{\Delta x}{\Delta t} = \dfrac{change\_in\_dis\tan ce}{change\_in\_time}$

- $acceleration = a = \dfrac{\Delta v}{\Delta t} = \dfrac{change\_in\_velocity}{change\_in\_time}$

For now simply become familiar with these concepts and their relationship to linear motion and with the instrumentation utilized to measure the previously mentioned vector quantities. When measuring these quantities, we are assuming

3. Objective:

- Have student gain familiarity with instrumentation hardware and software.

- Have student gain familiarity with concepts of linear motion.
- Demonstrate the use of sensors in acquiring real-time data.
- Analyze the motion of a student walking across the room.
- Predict, sketch, and test distance/velocity *vs*. time kinematics graphs.

4. Equipment List

- Power Macintosh or Windows PC   - LabPro or Universal Lab Interface
-Logger Pro   -Vernier Motion Detector
-Meter Stick   -Masking Tape or Marker

5. Experimental Procedure

Part I Preliminary Experiments

1. Connect the Motion Detector to DIG/SONIC 2 of the LabPro or PORT 2 of the Universal Lab Interface. (Note that the second input is used in both cases!)

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.

3. Open the Experiment 1 folder from *Physics with Computers*. Then open the experiment file Exp 01a Distance Graph. 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.

5. Sketch what the distance *vs.* time graph will look like if you walk faster. Check your prediction with the Motion Detector.

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.

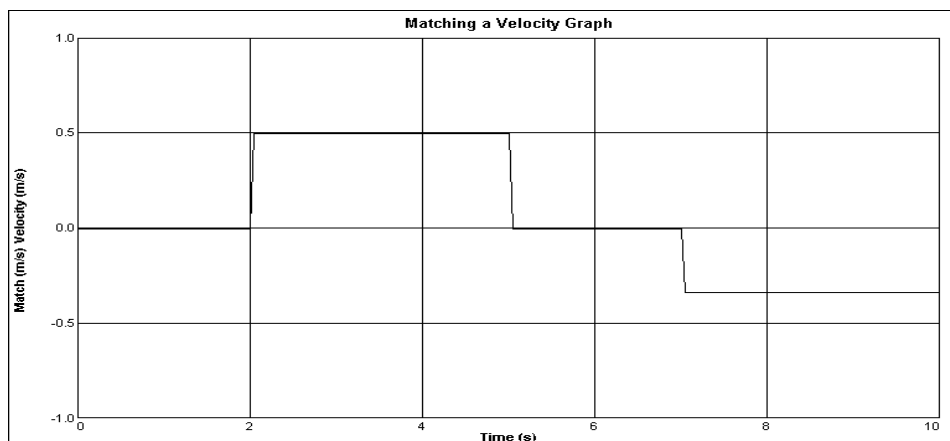Part II Distance vs. Time Graph Matching
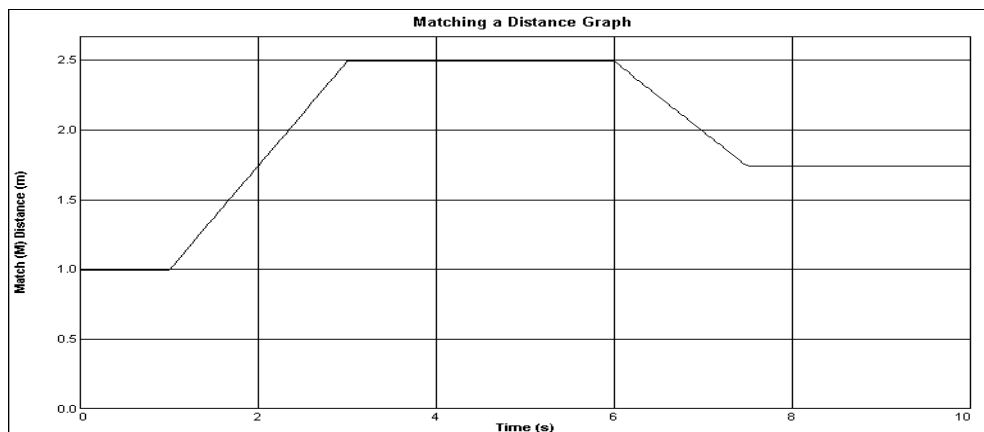
7. Describe how you would walk to produce this target graph.

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.

10. If you were not successful, repeat the process until your motion closely matches the graph on the screen. If a printer is attached, print the graph with your best attempt.

11. Walk in such a way that would produce the following graph.

Matching a Distance Graph
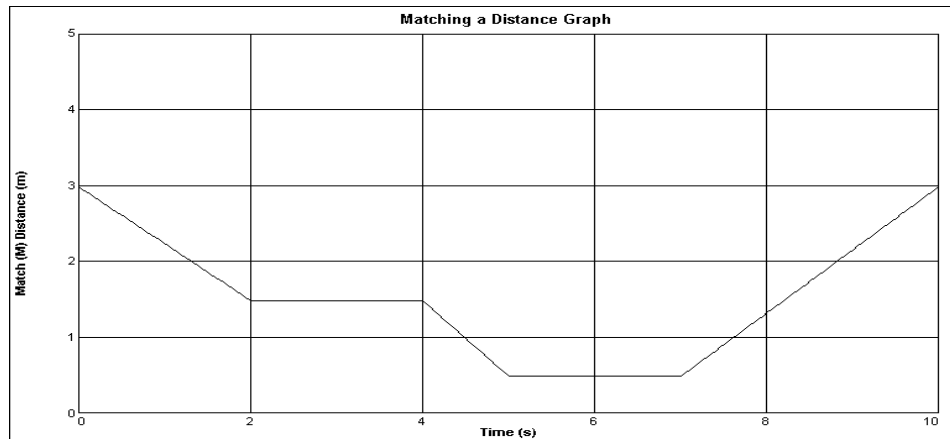
12. Answer the Analysis questions for Part II before proceeding to Part III.

<u>Part III Velocity vs. Time Graph Matching</u>

Matching a Velocity Graph

13. Describe how you would walk to produce this target graph.

14. 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.

15. Perform the same task, so as to replicate the following graph.

Matching a Velocity Graph
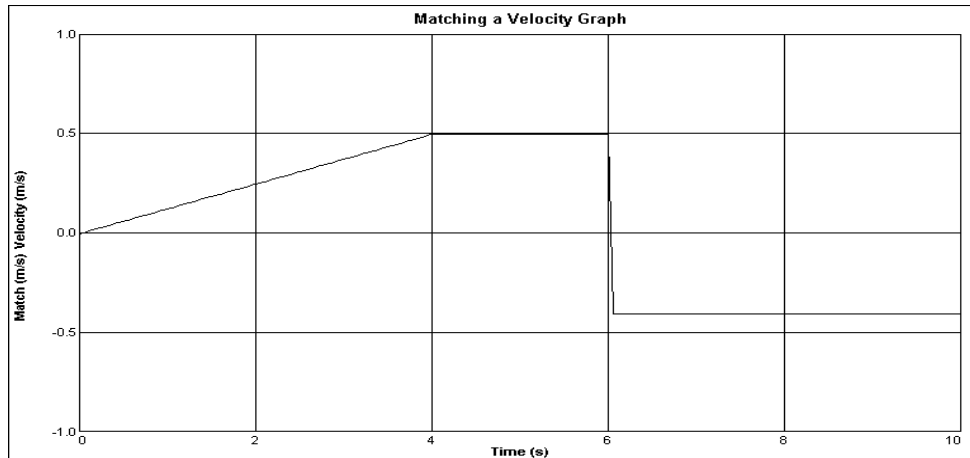
16. Remember to remove the masking tape strips from the floor.

6. Results

When standing still the distance is not going up or down and there for it will appear as a straight line. When moving away from the motion detector, with any velocity the program creates a graph with a positive slope, however when moving towards the motion detector, a graph is produced with a negative slope. Therefore when there is a positive slope, the distance between you and the motion detector is increasing, and when the distance is decreasing the slope will be negative.

7. Analysis/Questions

Part I Distance *vs*. Time Graph Matching

1. No Questions for Part I

Part II Distance *vs*. Time Graph Matching

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

3. Explain the significance of the slope of a distance *vs*. time graph. Include a discussion of positive and negative slope.

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

5. What type of motion is occurring when the slope of a distance *vs*. time graph is constant?

6. 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.

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.