Physics Lab Activity

Kinematics Graphs

Purpose:

When you finish this activity, you should be able to:

- Sketch a position vs. time graph for a described one-dimensional motion.
- Describe a one-dimensional motion given a position vs. time graph.
- Sketch a velocity vs. time graph for a described one-dimensional motion.
- Describe a one-dimensional motion give a velocity vs. time graph.

Equipment:

Motion Detector and Pasco™ 500 interface	Worksheet 1 - Position vs. Time
DataStudio™ software	Worksheet 2 - Velocity vs. Tme
masking tape	
meter stick	

Description:

A graph of position vs. time and/or velocity vs. time is one of the most effective ways to describe motion. In this lab, you will use a "motion detector" linked to a computer or calculator to automatically draw kinematics graphs in real time for *your* one-dimensional motions. This makes it easy and natural for you to connect kinematics graphs and the motions they represent.

This activity is divided into two parts. In the first part, you will be asked to predict what the graph of a motion would look like, and then actually execute that motion and compare the resulting graph. In the second part, your lab partners will draw a graph and challenge you to perform the motion that will produce the graph.

It will help to understand what's going on. "Motion detectors" don't actually detect motion. They work by sending out a high-frequency sound pulse which strikes an object (you, in this lab) and reflects back to the detector. By precisely measuring the time for the pulse to return, the software can determine the distance to the reflecting object.

For example, suppose that it takes a signal 0.017 seconds to travel to you and reflect back to the detector. Knowing that the speed of sound is about 340 m/s, the distance traveled by the pulse is easy to calculate:

total distance traveled = (average velocity)(time) = (340 m/s)(0.017 s)

total distance traveled = 5.8 m

The distance from the detector to you is half of the total distance = 5.8 m/2 = 2.9 m

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Knowing the time and distance to the object it is pretty straightforward to draw the graph, and the software can construct the graph in "real time", so you can watch the graph being drawn as you move.

The software calculates your velocity from the distance and time data that it collects. For example, if you were detected 2.9 meters from the detector at 1.55 seconds, and 3.0 meters from the detector at 1.60 seconds, your velocity would be calculated as:

$$\text{ave. velocity} = \frac{\text{displacement}}{\text{time}} = \frac{3.0\,m - 2.9\,m}{1.60\,s - 1.55\,s} = 2.0 \text{ m/s}$$

Hints:

Right now you are probably saying "Wow! This lab is computerized! What could possibly go wrong?" Well...

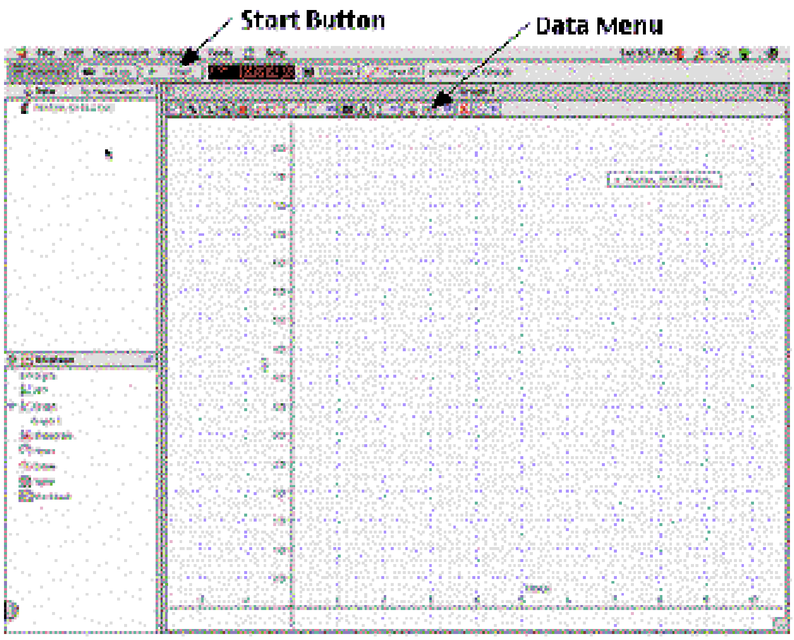
The reflection of the sound waves is not entirely reliable. Be sure that you are performing your motion in a clear area - no nearby walls, all furniture and extra people out of the way. If you can't get a good graph, try re-aiming the detector or moving nearby objects out of the way. It may help to hold a large piece of cardboard in front of you to reflect the waves better.

In any case, your graph won't be perfectly "clean" and smooth. You will need to ignore the "glitches" in the graph, if possible (unless you really are jumping several meters and back in a hundredth of a second...). Keep in mind that since velocity is calculated from position, any slight problems in the position vs. time graph will be magnified in the velocity vs. time graph. Since accelerations are calculated from velocities in this software, acceleration vs. time graphs are pretty much impossible, but you can try them if you have time. If your software allows "smoothing" of your graphs, take advantage of it.

Keep in mind that the motion detector will not work well for objects closer than about 40 cm or farther than 4-6 meters.

Procedure:

1. Position the motion detector so that it is abdomen/chest high, with a clear area at least 4 meters long (and 2-3 meters wide) in front of it.
2. For easy reference as you move, put small strips of masking tape on the floor at 1 meter, 2 meters, 3 meters, and 4 meters from the detector. Don't forget to remove this tape when you are finished!
3. Part 1:
    a. Double click the experiment file "position_vs_time.ds" which you will find in your Group Shared folder. This will start the DataStudioTM software and load the experiment file The screen should look like the picture below.



    b. How it works:
        1. When you press the Start Button, the computer will delay for 3 seconds, and then then motion detector will run for 10 seconds and automatically shut off. A graph of position vs. time for your motion will be displayed.
        2. To graph a second motion, just press Start again. To make the display easier to read, you can pull down the Data Menu and click on the previous run to uncheck it and remove it from the graph.
    c. For each motion described in the [position vs. time worksheeet](), first draw what you predict the graph will look like for the described motion on the axes on the left {"Predicted"). This prediction might not be very accurate at first, but you should get better with practice. Then, one person in your group will actually perform the motion and you can sketch the graph of the motion on the axes on the right ("Measured"). Be sure to take your turn performing the motions.
4. Part 2:
    . Open the experiment file "velocity_vs_time.ds". It operates just like the position vs. time experiment file, except that it produces a graph of velocity vs. time.

Then, one person in your group will actually perform the motion and you can sketch the graph of the motion on the axes on the right ("Measured"). Be sure to take your turn performing the motions.