Experiment P02: Understanding Motion II – Velocity and Time
(Motion Sensor)

file: MOT2_PLT

Objective:

The purpose of this activity is to introduce the relationships between the motion of an object – YOU – and a Graph of velocity and time for the moving object.

Apparatus:

Science Workshop Interface, base and support rod, motion sensor

Note: this activity is easier to do if you have a partner to run the computer while you move.

THEORY

When describing the motion of an object, knowing where it is relative to a reference point, how fast and in what direction it is moving, and how it is accelerating (changing its rate of motion) is essential. A sonar ranging device such as the Motion Sensor uses pulses of ultrasound that reflect from an object to determine the position of the object. As the object moves, the change in its position is measured many times each second. The change in position from moment to moment is expressed as a velocity (meters per second). The change in velocity from moment to moment is expressed as an acceleration (meters per second per second). The position of an object at a particular time can be plotted on a graph. You can also graph the velocity and acceleration of the object versus time. A graph is a mathematical picture of the motion of an object. For this reason, it is important to understand how to interpret a graph of position, velocity, or acceleration versus time. In this activity you will plot a graph in real-time, that is, as the motion is happening.

PROCEDURE:

For this activity, you will be the object in motion. The Motion Sensor will measure your velocity as you move in a straight line at different speeds. The *Science Workshop* program will plot your motion on a graph of velocity and time. The challenge in this activity is to move in such a way that a plot of your motion on the same graph will "match" the line that is already there.

PART I: Computer Setup

1. Connect the *Science Workshop* interface to the computer, turn on the interface, and turn on the computer.

2. Connect the motion sensor's stereo phone plugs to Digital Channels 1 and 2 on the interface. Connect the yellow-tape plug to Digital Channel 1, and the other plug to Digital Channel 2.

3. Open the *Physics lab folder* found on the desktop screen, then open the file: MOT2_PLT

- The document has a Graph display of Velocity (m) and Time (sec). The Graph shows Velocity and Time values that were put into the Graph using the "Load Data…" feature (see the User's Guide for *Science Workshop*).

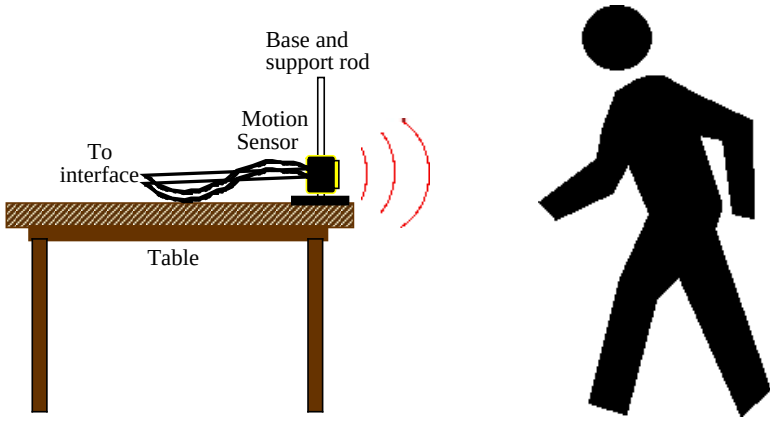
PART II: Sensor Calibration and Equipment Setup

- You do not need to calibrate the motion sensor for this activity. Motion that increases the distance from the motion sensor is considered "positive" motion. Motion that decreases the distance from the motion sensor is considered "negative" motion.

1. Mount the motion sensor on a support rod so that it is aimed at your midsection when you are standing in front of the sensor. Make sure that you can move at least 2 meters away from the motion sensor.

• NOTE: You will be moving backwards for part of this activity. Clear the area behind you for at least 2 meters (about 6 feet).

2. Position the computer monitor so you can see the screen while you move away from the motion sensor.



PART III: Data Recording

1. Click on the Graph of Velocity versus Time to make it active. Enlarge the Graph until it fills the monitor screen.

2. Study the Velocity versus Time plot in order to determine the following:

- Which direction (increasing or decreasing separation) should you go at the beginning? _____
- What is the maximum speed (positive or negative) you must achieve? _____ (m/s)
- How long should the positive velocity portions of your motion last? _____ (sec)
- What should your acceleration be during the positive velocity portions of your motion?

_____ (m/s^2)

3. When you are ready, stand in front of the motion sensor about 0.4 meters away. WARNING: You will be moving backward, so be certain that the area behind you is free of obstacles.

4. Click the "START" button to begin recording data. (Data recording will begin almost immediately. The motion sensor will make a faint clicking noise.)

5. Watch the plot of <u>your</u> motion on the Graph, and try to move so that the plot of your motion matches the Velocity vs Time plot that is already there.

- The aim of this activity is to understand the relationship between the velocity and time. Therefore, first try to move watching the velocity vs time plot, which is the upper graph on the screen. If you have difficulty in matching the plot, then try to move watching the position vs time plot, which is the lower graph on the screen. The lower graph is the integrated velocity of the upper one with respect to time.

- Data recording will end automatically after a certain amount of time, or click on "STOP" to end sooner. Run #1 will appear in the Data list in the Experiment Setup window.

6. Repeat the data recording process a second and a third time. Try to improve the match between the plot of <u>your</u> motion and the plot that is already on the Graph.

OPTIONAL

The Graph can show more than one run of data at the same time. You can display up to three runs simultaneously. If you record more than three runs, use the DATA menu along the vertical axis to select the runs you want to see. To delete a run of data, click on the run in the Data list in the Experiment Setup window and press the "delete" key on the keyboard.

<u>ANALYZING THE DATA</u>

1. Use the mouse to click-and-draw a rectangle around the middle of the positive velocity portion of your motion. Use the "FIT" menu button in the tool bar area of the Graph. Select "Linear Fit" from the Curve Fit menu to display the slope of the selected region of your velocity vs time plot.

2. Examine the slope m, what is the average acceleration of your motion. To find the average click on the Statistics ("∑") button on the tool bar.

<u>QUESTION</u>

1. For your best attempt, how well did <u>your</u> plot of motion fit the plot that was already on the Graph? Calculate the percent difference of the linear slope of your motion and the slope of the given graph.

Expected acceleration a _____(m/s^2)
Actual acceleration a2 _____(m/s^2)

Percent error= $\frac{|a - a2|}{a} \times 100\%$ **= _____%**