Kinematics

Objective

The purpose of this experiment is to develop a physical and graphical understanding of position, velocity, and acceleration and their relationship to one another. A sonic ranger (sometimes called a motion sensor) allows you to graph the position, velocity, and acceleration of an object as functions of time. This motion sensor emits a conical beam of ultrasound waves; objects obstructing the beam reflect some of these waves back to the sensor. By measuring the time it takes the beam to be reflected back from an object, the software calculates the position of the object and, if it is moving, also its velocity and acceleration.

Materials

1. 1-meter stick
2. Pasco 550 Interface
3. Sheet of Cardboard
4. Sonic ranger

Procedure

Connect the two leads (wires) from the sonic ranger (motion sensor) to the Pasco 550 Interface. Connect the yellow lead to digital Channel #1 and the black lead to Channel #2. To begin gathering data, you will need to open the Pasco Capstone program on your desktop. Double click on "Hardware Setup" (in the "Tools" window panel on the left side of screen). Click on digital input #1 on the interface and select "Motion Sensor II". Next, you'll need to create the graphs that will display your motion. On the "Displays" window panel, double-click on "Graph". Click on "Select Measurement" on the vertical axis of your graph and choose "Position". You will want to display not only position
vs time but also velocity vs time. To do this, click on to add a new y-  axis to your scope display. (A "Select Measurement" button will pop up on the right side of your scope.) Click on "Select Measurement" on the left of your scope and choose "Velocity". You should now have two graphs displayed on top each other. You should make these graphs as large as you can by clicking and dragging on the bottom right corner of the graph window.

Part A: Position and Velocity vs Time Graphs, Recording

In this part of the lab you are going to analyze position, velocity vs time graphs for four different types of motion (two constant velocity cases and two increasing velocity cases). Before you take data for each case you are to sketch your predictions for what you think the two graphs (position, velocity) will look like. On a piece of graph paper draw two sets of axes. Label the axis and title each graph (place position vs time at the top, velocity vs time at the bottom). Only predict the graphs for one of the four motions (below) at a time (do not make your predictions for all four motions at the beginning of the lab).

On each graph you will have one line that represents your prediction and one line for what the motion actually looked like. Do not be concerned if your predictions are incorrect. This lab is supposed to be a learning experience; people usually learn more from mistakes. You will not be counted off if your predictions don't agree with what actually happened (moreover, your lab instructor might be suspicious of you if all of your predictions in this lab are correct!). Use dashed lines to distinguish your predictions from your actual data (label which is which on your graphs).

To start taking data you will simply click on the "Record" button at the bottom-left side of your screen. As soon as you have made the motion, click "Stop". With each new motion (or if you get bad data) you will want to get rid of the older data. The easiest way to do this is to click on the arrow next to the "Delete Last Run" tool at the bottom of the screen, and select the specific run or "Delete All Runs". There will be times when your sonic ranger misses you or when the axis of the graphs has too large of a scale on them to properly display your data (you are not interested in looking at the occasional spikes on your graphs where the detector missed you). The easiest way to scale down the axis of your graphs is to click and drag your mouse on one of the numbers on that axis (you'll see a crooked arrow when you move your mouse over a number).

Below is the list of the four motions/movements you are to make in front of your sonic ranger (using your hands to move a piece of cardboard). To begin hold your piece of cardboard about 0.5 meters (50 cm) away then click "Record".

<u>**Note**</u>: Your sonic ranger will not work for distances closer than 0.40 m; be sure not to go closer than this (you'll get bad data).

Motions.

Again, you must make your predictions before each of these four motions.

1. Motion at constant velocity away from the motion sensor from 0.5 m to 1.5 m.
2. Motion at constant velocity toward the motion sensor from 1.5 m to 0.5 m.
3. Motion at steadily increasing rate away from the sensor from 0.5 m to 1.5 m.
4. Motion at steadily increasing rate toward the sensor from 1.5 m to 0.5 m

Be sure to lock your time axis by right-clicking at the bottom of your graph, clicking settings then selecting "Lock x axis". This will help to align the x-axis of the three graphs. In your report you must describe the relationships between your position and velocity graphs: do they change shape/direction at the same time? Why? Also in your report you need to discuss what constant velocity should look like for position vs time and velocity vs time graphs (in both directions) and what increasing velocity should look like (in both directions).

Part B: Position and Velocity vs Time Graphs, Predicting

In this part you should try to predict both “position vs time” and “velocity vs time” graphs for motions that are a little more complicated than those above.

1. Motion at constant velocity towards the sensor from 1.5 m to 0.5 m, then back to 1.5 m at the same speed.
2. Move towards the sensor from 1.5 m, starting fast and slowing constantly during the motion, coming to a stop just at 0.5 m.
3. Move from 0.5 m to 1 m at a constant velocity, stop for 2 seconds, then from 1 m to 1.5 m with increasing velocity.

Explain differences between your predictions and the computer’s graphs. Be sure to comment on the meaning of negative velocities. Compare your predictions with the computer’s measurements.

Part C: Replicating Motion Described in Graphs

The computer has graphs from previously recorded motions. You will interpret these graphs and understand the motion they describe, then recreate the motion while recording with the sonic ranger and compare results. To open these pre-made files, go to “File” and “Open.” In the LabDSFiles folder open the file “P01 Position and Time.” If need be, enlarge this position-time graph. Examine it and think carefully about how you will have to move to replicate it. (Where should you start? When should you start to move? How far should you go? How fast?)

Click the “Start” button and try to reproduce the lines on the screen with your own motion. When you are satisfied with your match, describe how you moved on your worksheet. (Section A)

Lastly, you will do a similar activity for a velocity-time graph. Again go to “File” and “Open.” In the LabDSFiles folder, open the file “P02 Velocity and Time.” Think carefully about the difference between a velocity vs time graph and a position vs time graph to help you understand how to reproduce this one. (Do you have to start at a particular position? How does movement away from the sonic ranger compare to motion toward the sonic ranger?)

Click the “Start” button and try to reproduce the lines on the screen with your own motion. When you are satisfied with your match, describe how you moved on your worksheet. (Section B)