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

Here are the hardware connections required for this lab:

1. Connect the sonic ranger lead to the “PasPort 1” input of Pasco interface.
2. Open Pasco capstone app on the lab computer.
3. Click on “Hardware setup” to make sure that “Motion Sensor, Ch P1” is connected.
4. Click “Hardware setup” again to put that menu away.

Next, you’ll need to create the graphs that will display your motion. On the “Displays” window panel (far right of screen), 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 the “Add new y-axis to active plot area” icon in the menu bar.

Click on “Select Measurement” on the newly-created y-axis (it will be on the right side of your graph) and choose “Velocity”. You should now have two graphs displayed on top each other. You should make this graph as large as you can by clicking and dragging on the bottom right corner of the graph window.

Part A: Position, Velocity vs Time Graphs

In this part of the lab you are going to analyze position and 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 graphs (position vs time, velocity vs time) will look like. On a piece of graph paper draw two sets of axes. Label the axes 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).

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!).

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). Another option is to explore the "Scale axes to show all data" tool.

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".

Note: Your sonic ranger will not work for distances closer than 0.40 m (40 cm); 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.
2. Motion at constant velocity toward the motion sensor.
3. Motion at steadily increasing rate (speeding up) away from the sensor.
4. Motion at steadily increasing rate (speeding up) toward the sensor.

As the computer generates the graphs, compare your predictions with your experimental results. Make sure you understand the relationships between your position vs time and velocity vs time graphs. Are they curves, horizontal lines, diagonal lines? Are the values positive or negative? Do the signs (+ or -) make physical sense to you?

Part B: Synthesis

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. For example, start with motion that involves going from 0.5 m out to 1.5 m at a constant speed and then back to 0.5 m at a constant speed.

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

Make up your own interesting motion. Predict velocity vs time graphs. Compare your predictions with the computer’s measurements.