LAB 1. GRAPHS OF MOTION

Supplies: Computer with Capstone installed; Science Workshop 750 interface; USB to interface cable; interface power supply; PASCO Motion sensor II with cable; flat panel ; dynamics cart; grooved aluminum track; books, boxes, or blocks to elevate one end of the track.

Configuring the system

1. Connect the power supply to the wall outlet and the Science Workshop interface. Connect the data cable to a USB port in the computer and the serial or USB port in the back of the interface. Connect the dual cable to the socket in the motion sensor. Plug the yellow plug into socket 1 on the interface, and plug the black plug into socket 2. Make sure the interface is turned on (the switch is in the back).
2. Launch the Capstone program by double clicking on its alias icon. If necessary, do what it says to connect to the interface. To recognize the motion sensor, click on channel 1 in the picture of the interface box. Set the sample rate to 40 Hz.
3. Select the display format from the options in the window. I like a data table and graph display, but that may not be one of the default options. At least choose a display that includes the graph. Select "Position" for the vertical axis and "Time" for the horizontal axis.
4. When your system is set up satisfactorily, sketch the apparatus in your lab notebook *in ink*.

Practice

Have someone (the "target") stand in front of the transmitter, holding the whiteboard in front of the detector to give a flat reflecting surface. To start data collection, click on the "Start" button. The target should practice moving toward and away from the detector at different speeds, speeding up, and slowing down. Capstone will generate a position-time graph during collection.

Practice positioning the Motion Detector and moving the target so that the plot is smooth and truly represents the target's position at all times, without jumps or spikes. Jumps and spikes are the bane of data taken with these motion sensors. This lab is a great time to wrestle with them, understand them, and minimize them. Common sources of error include the target moving out of the ultrasound beam and nearby objects reflecting the beam back at the detector.

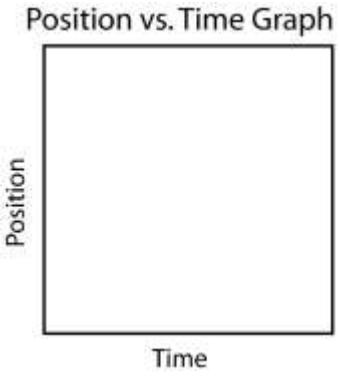
Practice using all of your group members who are present as targets.

Taking Data

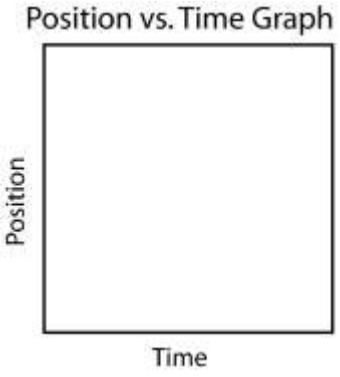
Position-time graphs from verbal descriptions

Here, you are given written descriptions of motion. Act out the motion in front of the probe while collecting data, and see what position-time graphs result. *Keep these data files* for later as well. Save the plot data and record the file name here and in your lab notebook.

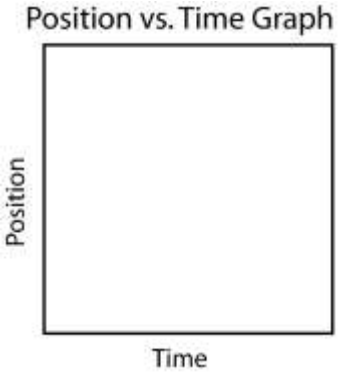
Walk steadily toward the probe, stop and wait a little while, and then walk steadily away from the probe.



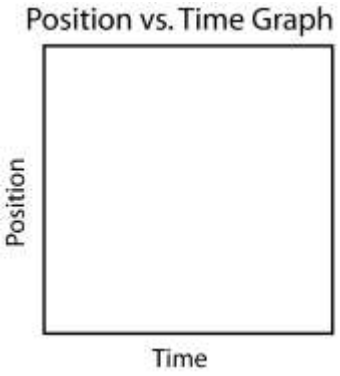
Walk slowly away from the probe, then immediately reverse direction and walk quickly toward it.



Walk away from the probe with increasing speed.



Alternate stepping toward the probe and stopping to rest.

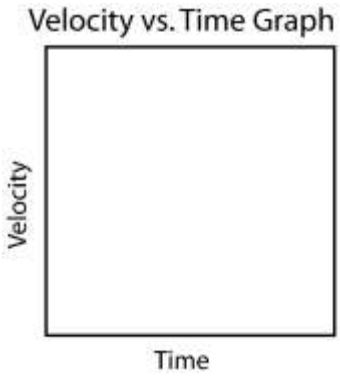


Study each written description and resulting position-time graph. Make sure you understand how and why they both describe the same motion.

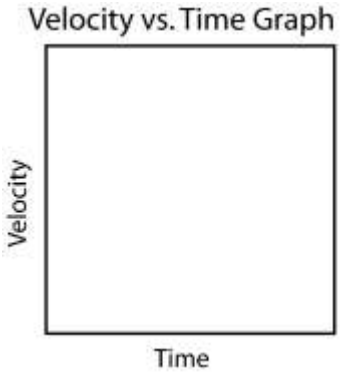
Velocity-time graphs from verbal descriptions

Now that you have an idea what position-time graphs look like, we'll move on to graphs of velocity. Velocity is the *rate of change* of position. You will use the scenarios described in "Position-time graphs from verbal descriptions" above. Pull up the data from those runs and plot their velocity-time graphs. Sketch them here.

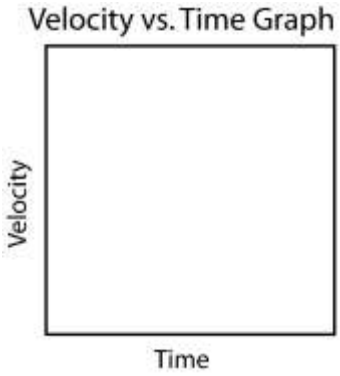
Walk steadily toward the probe, stop and wait briefly, and then walk steadily away from the probe.



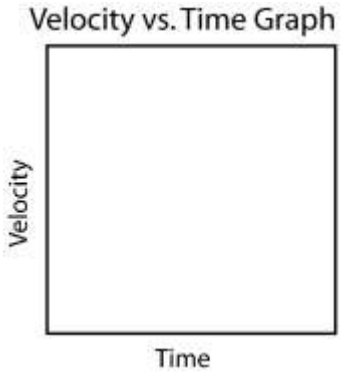
Walk slowly away from the probe, then immediately reverse direction and walk quickly toward it.



Walk away from the probe with increasing speed.



Alternate walking toward the probe and stopping.



Study each written description and resulting position-time and velocity-time graphs. Make sure you understand how and why they all describe the same motion.

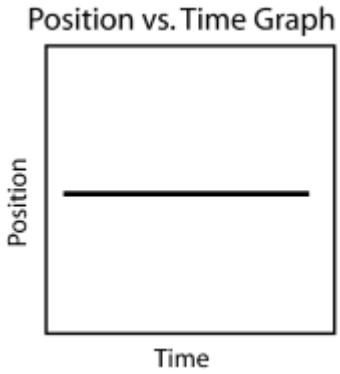
Match the position-time graphs

Look at the graphs below. Interpret what each graph means. Plan the motion of a target that corresponds to each graph.

When you are ready, have the target move to duplicate each graph while collecting data. Keep trying until the graph you produce really looks like the model. Repeat with each person in your group as the target so that everyone gets a kinesthetic feel for what the graphs mean. Keep the best run for each graph and record its name here and in your lab notebook.

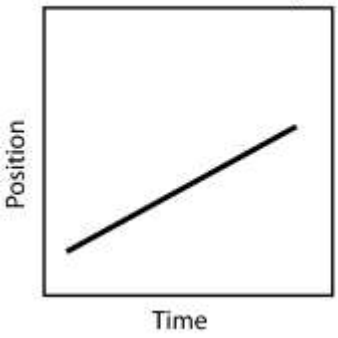
In the space to the right of each graph, describe the target's motion in words. Do not use the words "velocity," "acceleration," "positive," or "negative." Instead, use phrases like "speed up," "slow down," "hold still," "faster," "slower," "toward the detector," and "away from the detector."

Keep your data from these graphs to use in the "Velocity plots" activity.



Description of Motion

Position vs. Time Graph



Description of Motion

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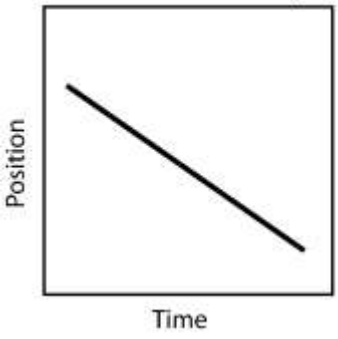
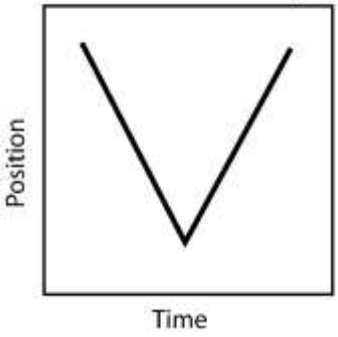
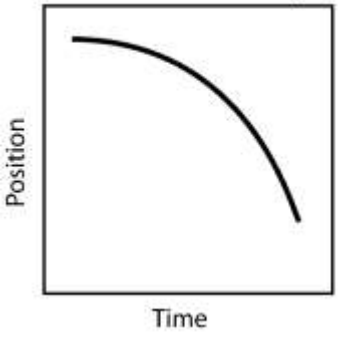
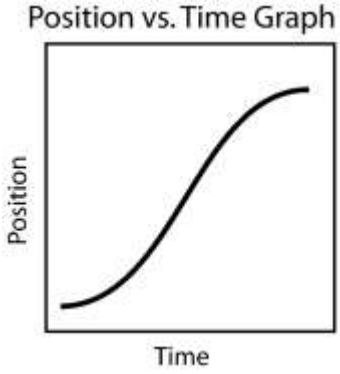


Position vs. Time Graph



Position vs. Time Graph



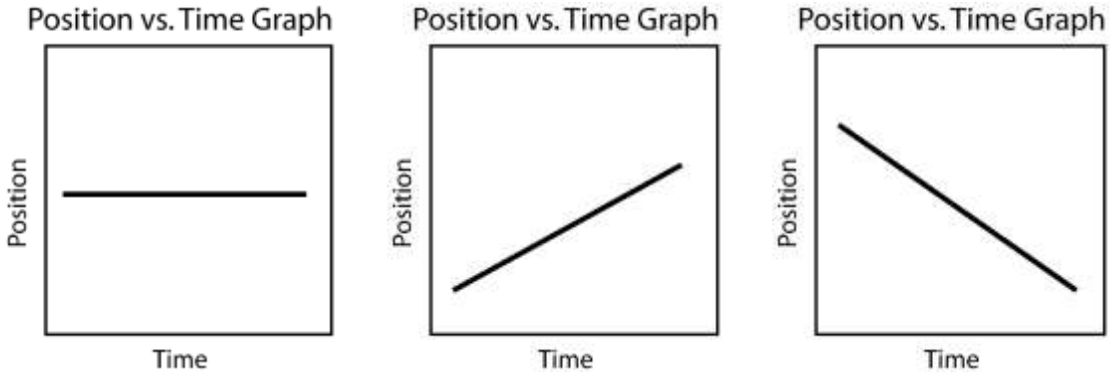


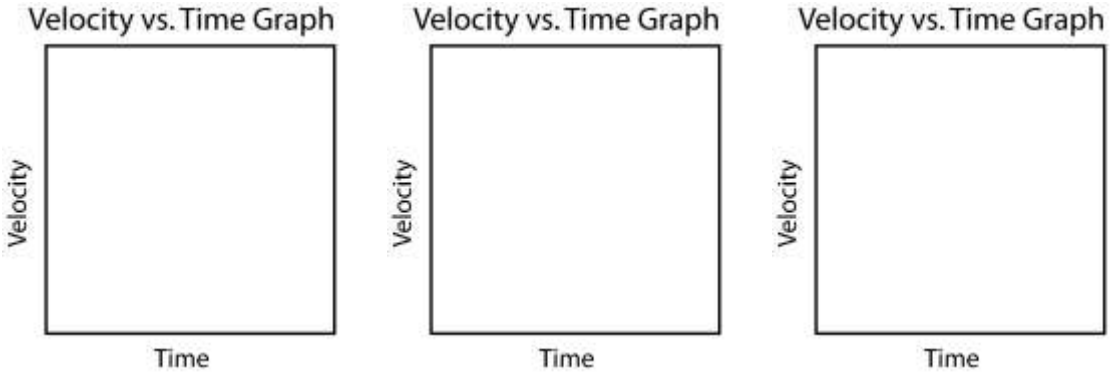
Description of Motion

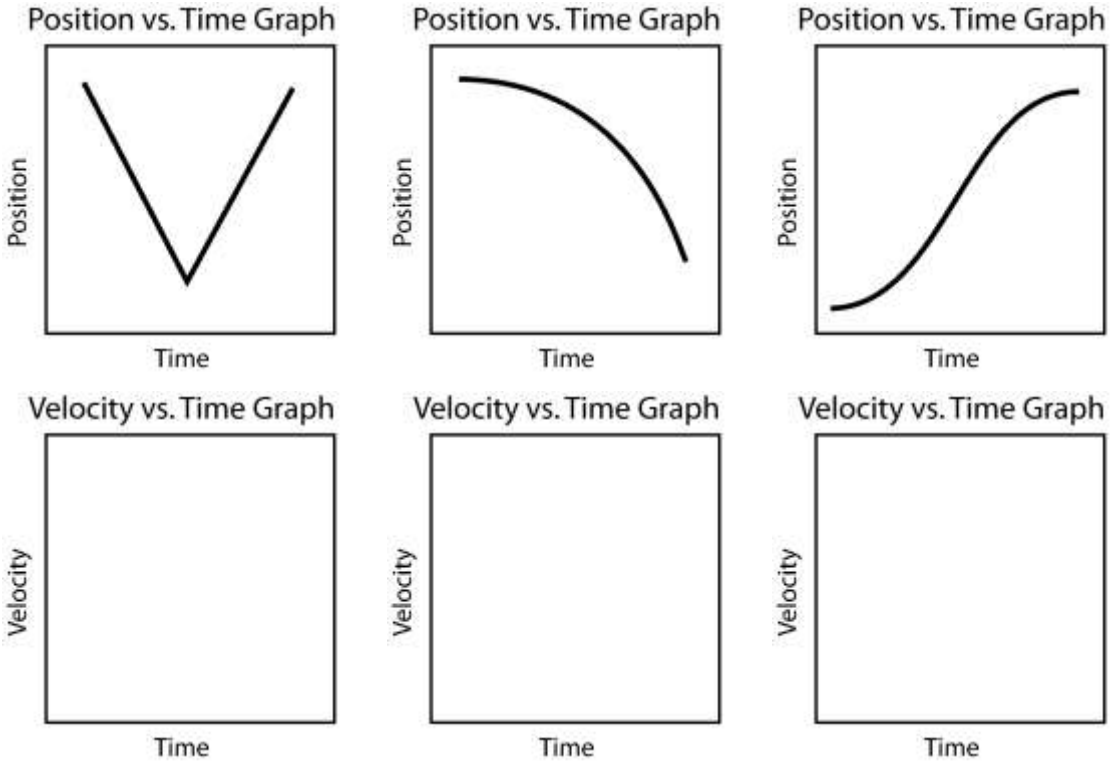
Study each graph and think of the motion that produced it. Make sure you understand how and why the graph describes the motion.

Velocity Plots

Using the data from your previous runs, sketch the velocity-time graphs corresponding to the position-time graphs in the spaces directly below them. To plot a velocity graph, change the vertical axis label of the graph to "velocity." You now should have axes for a velocity-time graph.







Study each graph and consider the motion that produced it. Make sure you understand how and why each graph describes the motion.

Rail cart

Obtain an aluminum track and a cart. Elevate the far end of the track and position the probe at the top of the slope. Practice giving the cart a quick shove so that it coasts almost to the top of the track and then back down. Don't let the cart run into the probe, and stop the cart when it returns to the bottom. Once you can make a satisfactory push reliably, collect data on the process. Record the the position-time, velocity-time, and acceleration-time plots that result. Sketch the graphs in ink in your lab notebook, showing the essential features. Show them to your instructor before you leave the lab. Your *instructor must sign off on your data* for it to be accepted.

Lab Report

There is not much to do for this lab, but I nonetheless require you to make a report following the standard lab report format. Here's what I want you to do in the different sections.

Abstract

This summarizes the investigation, including procedure and conclusions.

Purpose

What question is investigated or hypothesis tested. A big part of this lab is to familiarize you with the data collection apparatus, but you are also exploring kinematics principles. What are they?

Theory
You identified the relevant principles in "Purpose." Here, explain what they are. How does the apparatus find and report position, velocity, and acceleration of the target objects?

Experimental
Describe the apparatus and procedure in enough detail for a reader to duplicate your experiment. You may include a sketch or sketches.

Observations and Data
Some of your data are written in the graphs in this sheet; some is in your bound lab notebook. In your report, tell where the data can be found.

Analysis and Discussion
Detail the meaning of your results, particularly pertaining to the "Purpose" above. How do position-time, velocity-time, and acceleration-time plots for the same motion relate to each other?

Describe possible sources of experimental error, and how errors might have affected your results.

Conclusion
Did these activities teach you anything about the relationship between position, velocity, acceleration, and time? Did they confirm anything you had been taught in class? Answer in a few sentences.