LAB 1. GRAPHS OF MOTION

Supplies: computer with Logger Pro installed; Lab Quest Mini interface; USB to interface cable; Motion Detector 2 with cable; flat panel ; dynamics cart; grooved aluminum track; brick, boxes or blocks to elevate one end of the track.

Configuring the system

1. Take a lab laptop from the cabinet. Disconnect is charging cable from the laptop and put the cable neatly back into the cabinet.
2. Connect the data cable from the Lab Quest Mini interface to a USB port on the computer. Connect the cable from the motion sensor to the "Dig1" or "Dig2" port on the interface. Then turn on the computer.
3. Find the Logger Pro program by clicking on the search icon (magnifying glass) in the task bar near the bottom of the screen. Search for "Logger Pro;" it should come up pretty quickly after you type "l." If it doesn't, consult your instructor. Launch Logger pro. The default display when Logger Pro detects the motion sensor should be a data table and two graphs. If you don't see that, consult your instructor.
3. To take measurements, first point the transceiver (the perforated metal circle) at the moving target. Then collect data by clicking on the "collect/stop" button on the screen, or by pressing the spacebar on the keyboard. As you take data, Logger Pro populates the cells in the data table and creates the graphs. To change the duration of data collection or other experimental parameters, select "Experiment > Data Collection" from the menu bar.

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. Start data collection. The target should practice moving toward and away from the detector at different speeds, speeding up, and slowing down. Logger Pro will generate a position-time graph during collection.

Practice positioning the motion sensor 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.

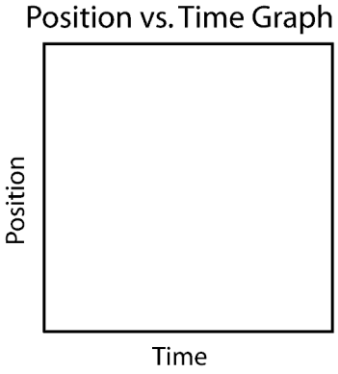
Practice using all of your group members who are present as targets.

Taking Data

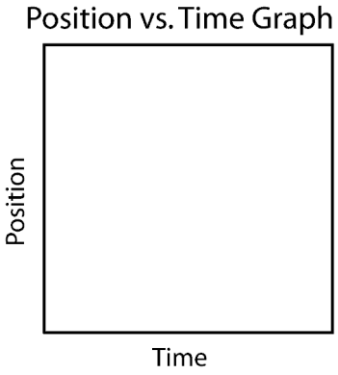
Position-time and velocity-time graphs from verbal descriptions

Here, you are given written descriptions of motion. Act out the motion in front of the probe while collecting data, and see what graphs result. Sketch the position-time graphs on the next page, and the velocity-time graphs on the page after that.

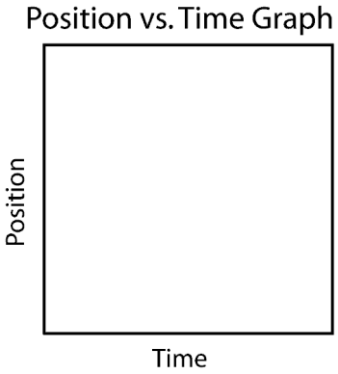
Walk steadily toward the probe, stop and wait a little while, and then walk steadily away from the probe.



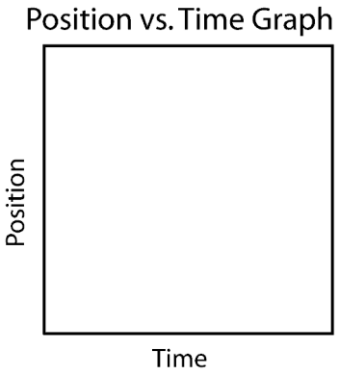
Walk slowly away from the probe, then immediately reverse direction and walk quickly toward it.



Walk away from the probe with increasing speed.



Alternate stepping toward the probe and stopping to rest.

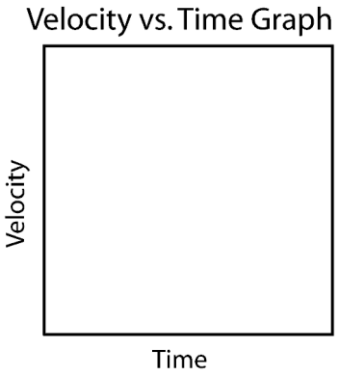


Study each written description and resulting position-time graph. Make sure you understand how and why they both describe the same motion.

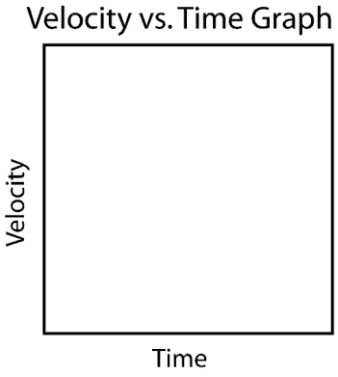
Velocity-time graphs from verbal descriptions

Velocity is the *rate of change* of position. Sketch the velocity-time graphs here.

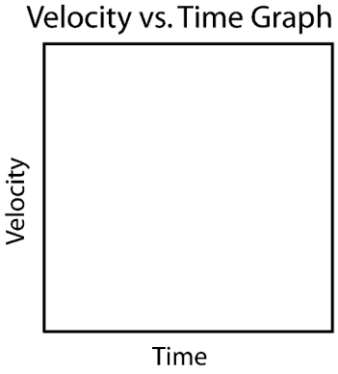
Walk steadily toward the probe, stop and wait briefly, and then walk steadily away from the probe.



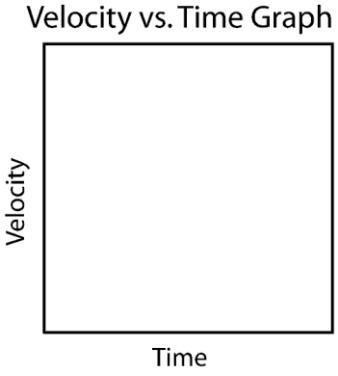
Walk slowly away from the probe, then immediately reverse direction and walk quickly toward it.



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

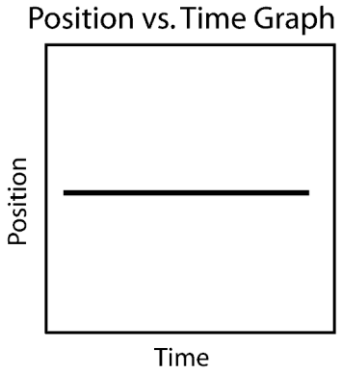
Look at the graphs below. Interpret what each graph means. Plan the motion of a target that corresponds to each graph.

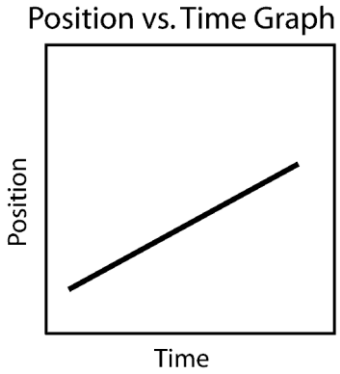
When you are ready, have the target move to duplicate each graph while collecting data. Keep trying until the graph you produce really looks like the model. Repeat with each person in your group as the target so that everyone gets a kinesthetic feel for what the graphs mean.

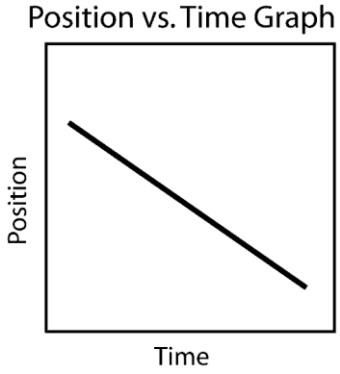
In the space to the right of each graph, describe the target's motion in words. Do not use the words "velocity," "acceleration," "positive," or "negative." Instead, use phrases like "speed up," "slow down," "hold still," "faster," "slower," "toward the detector," and "away from the detector."

When you finish with each position-time graph, go to the "Velocity Plots" activity (the next activity) to sketch the velocity-time graph that corresponds to each position-time graph.

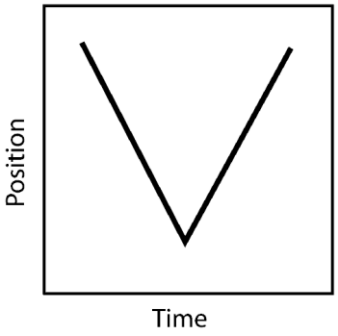
Description of Motion





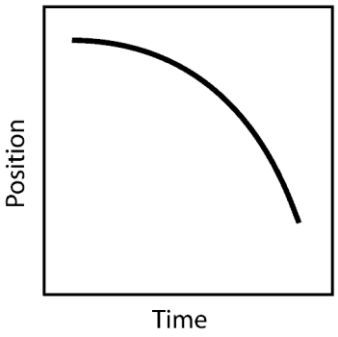


Position vs. Time Graph

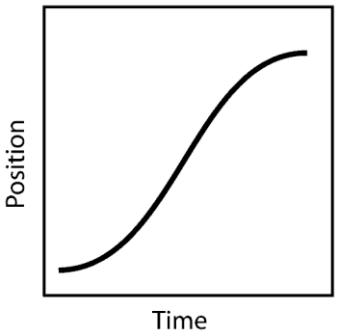


Description of Motion

Position vs. Time Graph



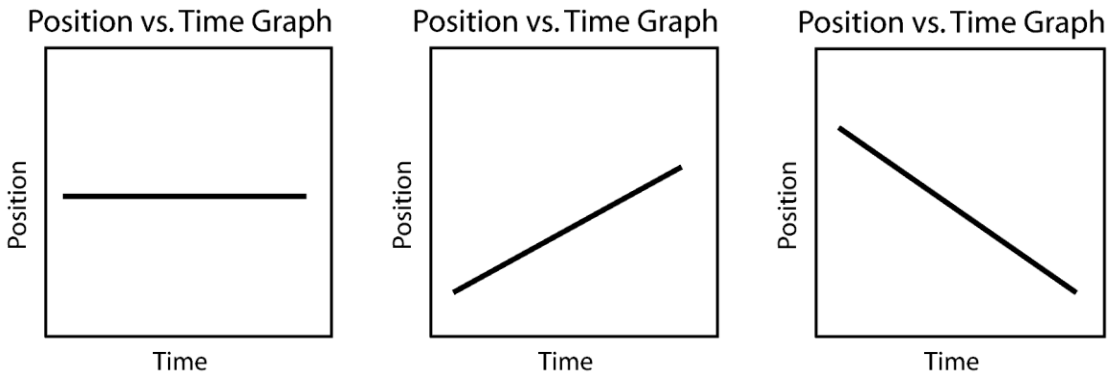
Position vs. Time Graph

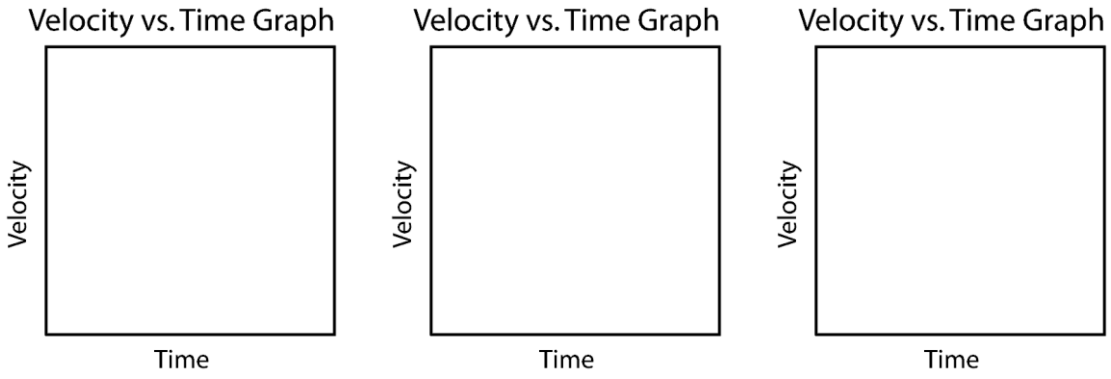


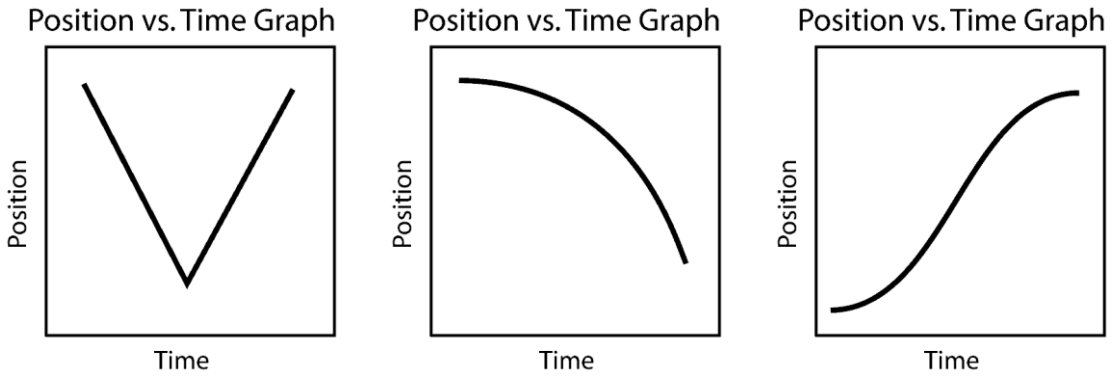
Study each graph and the description of the motion that produced it. Make sure you understand how and why the graph describes the motion.

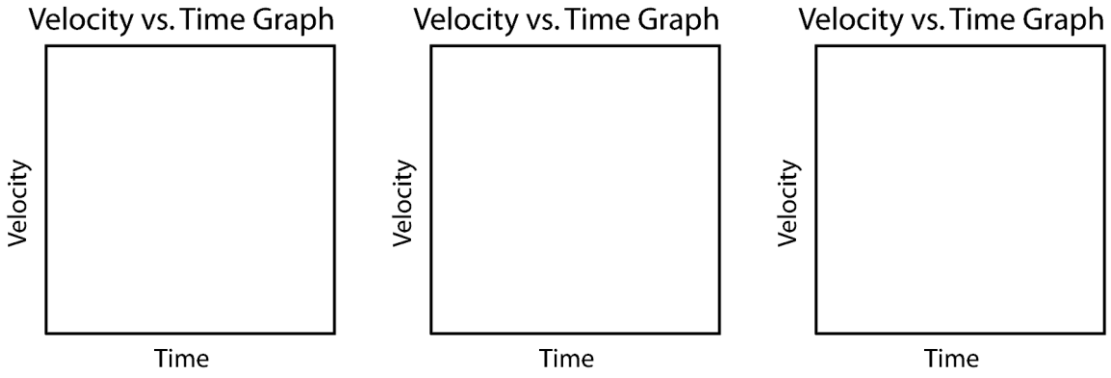
Velocity Plots

Sketch the velocity-time graphs corresponding to the position-time graphs in the spaces directly below them.









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 catch the cart when it returns to the bottom. Once you can make a satisfactory push reliably, collect data on the process. Record the position-time, velocity-time, and acceleration-time plots that result. Sketch the graphs below with their axes, 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 want you to make a report following the standard lab report format. *This may be a group report.* Here's what I want you to do in the different sections.

Abstract

I'll do this part for you, so that you have an example of an abstract for future labs.

"The Vernier motion detector with Logger Pro software was used to record the motion of experimenters moving toward and away from the sensor and of a dynamics cart coasting on an inclined track. The position-time, velocity-time, and, for the dynamics cart, acceleration-time graphs were studied to become familiar with the plots resulting from the different motions."

Purpose

"These activities were intended to help us understand the relationship between position, velocity, and acceleration, and how this is communicated by plotting these quantities over time. They also acquainted us with the motion sensor and Logger Pro software."

Theory

"Position x along one axis changes with time. Velocity v is the rate of change of position: $v = dx/dt$, and acceleration is the rate of change of velocity: $a = dv/dy = d^2x/dt^2$. Geometrically, this means that velocity is the instantaneous slope of a position-time graph, and acceleration is the instantaneous slope of a velocity-time graph. Accordingly, acceleration is correlated to the curvature of a position-time graph."

Experimental

Describe the apparatus you used and the procedure you followed in enough detail for a knowledgeable reader to duplicate your experiment. Yes, the procedure is given in this lab sheet, but I want you to explain it in your own words. You may include a sketch or sketches.

Observations and Data

That's all recorded on this lab sheet. Submit this lab sheet as part of your report.

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? Give specific examples.

You hope that your measurements faithfully record what happened in your experiments. However, it is possible that the measurements don't actually match the reality. Think of what could have happened in taking your measurements that would cause them to be erroneous. Also think of how these errors or inaccuracies would affect your calculations or conclusions. In this section of your lab report, describe plausible sources of experimental error, and predict how such 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.