

Position, Velocity, and Acceleration




Microcomputer-Based Lab

In this experiment you will investigate the motion of a single cart on a track. The main goal of the experiment is to investigate the connections between the three graphs associated with the motion, which show the position, velocity, and acceleration of the cart as a function of time.

PROCEDURE


First, take an ultrasonic motion sensor and slide it onto one end of the 2.2-meter track. Then plug the cable from the motion sensor into channel 1 on the LabPro interface, and make sure all other cables are removed. Double-click on the Logger Pro icon titled “Position, Velocity, and Acceleration”. This should start the software with three graphs, one for position, one for velocity, and one for acceleration, displayed on the screen.

Investigating the connection between the graphs

1. Place the cart so it is at rest at some convenient point near the middle of the track. This will be your origin, but you need to tell the software that. To do that, keep your hands clear of the cart and click the  button. You should hear the motion sensor clicking as it sends out pulses to determine where the cart is.
2. Hit the  button and move the cart back and forth. Which direction is the positive direction?
3. With the track horizontal, hit the  button and push (and then release) the cart so it rolls in the positive direction. Repeat this at least three times, starting the cart first from the origin, then from a positive position and then from a negative position.
4. Repeat step 3, but this time push the cart in the negative direction.

Question 1: Why does the cart keep rolling after you let it go?

Question 2: What is the difference between a positive position and a negative position? What is the difference between a positive velocity and a negative velocity? Did you observe situations where the cart’s position was positive but its velocity was negative, or vice versa? Briefly describe in everyday language what both of these situations mean.

5. Now incline the track by raising one of the track supports (resting one support on a black bar is a good way to do this). Choose a point to release the cart from, and hit the  button and release the cart (from rest) when you hear the motion sensor start clicking.

Question 3: Carefully examine the position and velocity graphs. At any particular instant in time something about the position graph corresponds to the velocity. What is it? As time goes by what happens to this something about the position graph? Does this make sense? Briefly explain.

Question 4: At any particular instant in time something about the velocity graph corresponds to the acceleration. What is it? As time goes by what happens to this something about the velocity graph? Does this make sense? Briefly explain.

Prediction 1: In step 6 you will release the cart from rest from a different position. Predict what, if anything, will change on each of the three graphs when you do this.

6. Store your first set of data on the screen by going to the Data menu and selecting “Store Latest Run”. Now repeat step 5 but release the cart from rest from a different (by at least 10 cm) point on the track.


Question 5: Comment on the similarities and differences you observe between your two data sets. For instance, how do the two acceleration graphs compare? Is this what you expected based on your prediction? Compare the two velocity graphs to one another, and compare the two position graphs to one another, too. Did these match your predictions?


Prediction 2: Next you will record data as the cart travels up the incline, stops for an instant, and then comes back down. What do you expect the three graphs to look like now? In particular note the differences you expect to see between motion on the way up and motion on the way down, and what, if anything, special happens on each of the graphs at the point where the cart comes to rest just for an instant.

7. Now, collect data with the cart rolling up, and then back down, the incline. Start with the cart at rest and including the period when you are pushing the cart up the incline.

Question 6: Can you tell from the graphs when you were pushing the cart up the incline? Is this easier to discern from one of the three graphs? If so, which?

Question 7: Now focus on the time period after you removed your hand from the cart. Comment on whether the three graphs matched your predictions. Elaborate in particular on any instances in which the graphs differ from your predictions.

Question 8: Again, focus on the time period after you removed your hand from the cart. On the acceleration graph, click-and-drag with the mouse to select a particular time interval. Determine the area under the curve over this time interval by clicking the integral button, . The area under the curve of the acceleration graph (or, in other words, the integral of the acceleration with respect to time) is equal to something on the velocity graph over the time interval you’re considering. What is it?

Question 9: Now click-and-drag with the mouse to select an interval on the velocity graph. Determine the area under the curve by clicking the integral button, . The area under the curve of the velocity graph (i.e., the integral of the velocity with respect to time) is equal to something on the position graph over the time interval you’re considering. What is it?

Question 10: As a special case select a time interval in which the cart is at exactly the same position (but going in opposite directions) at both the start and the end of the interval. For this time interval what is the area under the curve of the velocity graph? Is this consistent with your answer to question 9?