

4.1 Acceleration

How does acceleration relate to velocity?

Acceleration is the rate at which velocity changes. The car accelerates as it rolls down the track. You can tell because the velocity changes.

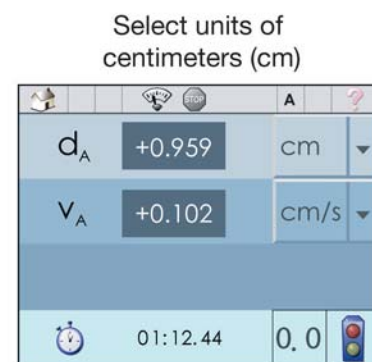
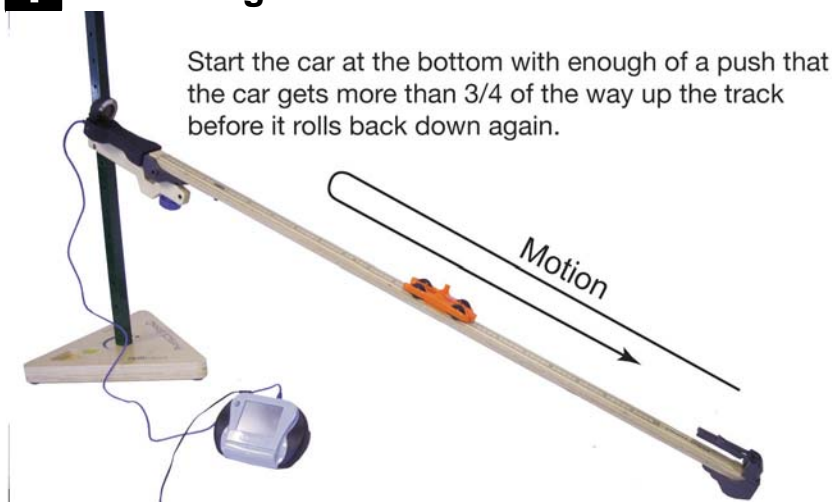
In this investigation, you will:

- measure position and velocity on a ramp.
- observe positive and negative velocity.
- use the velocity data to calculate acceleration.

Materials List

- DataCollector
- SmartTrack
- Energy Car
- Physics Stand
- Distance-Velocity sensor

1 Observing acceleration



Observe the position (x) velocity (v) and acceleration (a) as the car goes up and down.

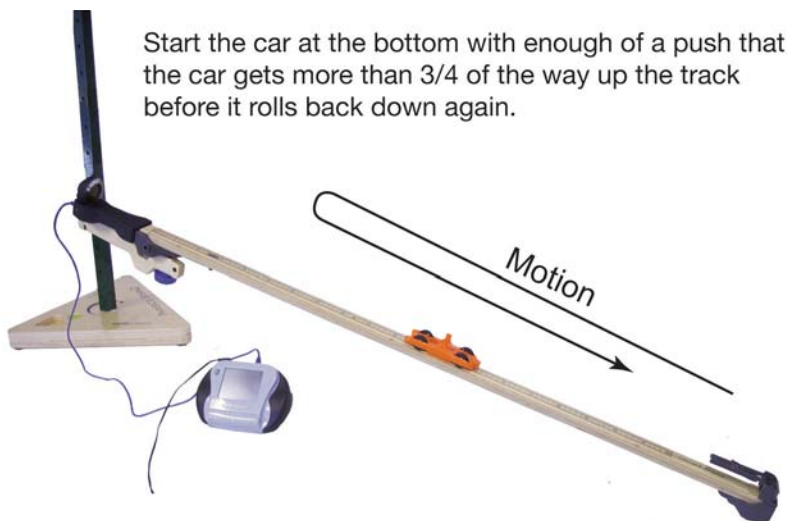
1. Set up the SmartTrack at a small angle as shown in the diagram, using the second hole from bottom of the stand.
2. Connect the distance-velocity sensor to input A of the DataCollector. Set the DataCollector to meter mode. Set the units to meters.
3. Put the car near the middle of the track. Move it back and forth with your hand while you watch the distance and velocity values.
4. Start the cart at the bottom and give it a short push so it rolls up the track, slows, reverses, and comes back down again.
5. Based on your observations, answer the following questions.

2 Observational questions

Suppose you move the car one way then reverse it and move it the other way.

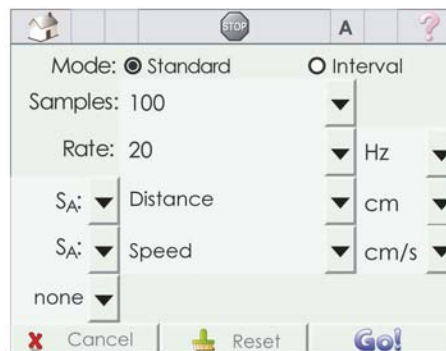
- a. When is the velocity positive? When is it negative?
- b. When do you think the largest acceleration occurs? Do you think it occurs when the velocity is highest? lowest? Do you think the largest acceleration occurs when the velocity is changing the most?
- c. When do you think the velocity and acceleration had the same sign?
- d. When do you think the velocity and acceleration had the opposite sign?

3 Acceleration and velocity



Start the car at the bottom with enough of a push that the car gets more than 3/4 of the way up the track before it rolls back down again.

Select 100 samples and set the rate to 20 Hz, or 20 samples per second.



1. Set the DataCollector to data collection mode and use the setup tab to set the samples to 100 and the rate to 20 Hz, which provides 20 samples per second. Click back to the meter tab and you should see the measurement screen that shows you time, position, and velocity.
2. Put the car at the bottom of the track. Get ready to push it up after another student hits the go button. Hit the go button and start the car rolling up the track using as much of the track as possible. Selecting 100 samples should be enough for the car to roll up and back down again.

4 Analyzing the data

- a. Once the DataCollector takes the samples, switch to table view. You should be able to scroll through the position and velocity. There may be a lot of "stopped" data both before and after the up-and-back data you really want to examine.
- b. Set the time (t) column to be X and set the velocity (v) column to be Y1. Switch to graph view.
- c. Describe the graph you see. Is it a straight line or a curve?
- d. Explain why the velocity versus time graph has positive and negative portions.
- e. The equation for a straight line is $y = mx + b$. Determine the slope, m , and the y-intercept, b , from the graph using the cursor. You will have to calculate the slope from the velocity and time at two separate points.
- f. Rewrite the equation for a straight line using the following variables: velocity, v ; initial velocity, v_0 , acceleration, a ; and time, t .
- g. Is the acceleration positive or negative?
- h. What is the meaning of the sign of the acceleration in terms of how the car moves on the track?
- i. Go back to graph view. Can you find a place where the velocity is zero but the acceleration is not zero? What was the car doing at that moment of its motion? Where on the track was the car when its velocity was zero?
- j. Draw a graph representing the acceleration versus time.
- k. Explain the relationship between the velocity vs. time graph and the acceleration vs. time graph. Why is one graph sloped while the other is relatively flat?