3.3 Equations of Motion

How are equations used in physics?

Equations provide quantitative relationships between variables such as position, time, velocity, and acceleration.

In this investigation, you will:

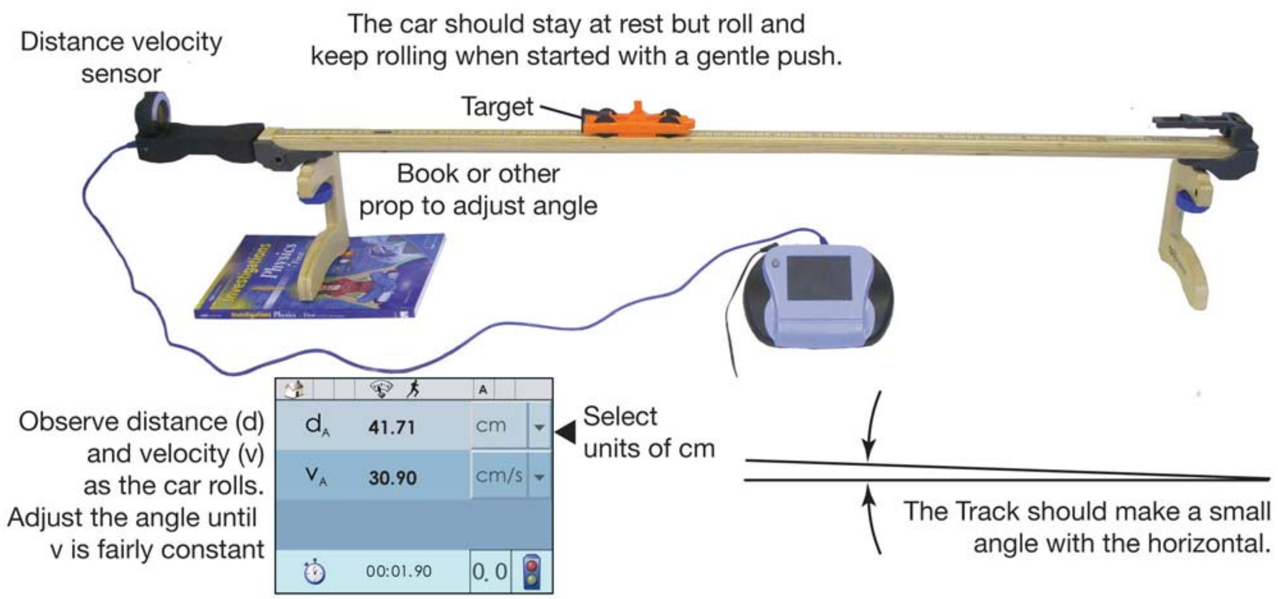
- create an equation for motion that includes four variables.
- determine parameters in the equation from data.
- test the equation against real data.

Materials List

- DataCollector
- SmartTrack
- Energy Car
- Some small books
- Distance-Velocity sensor

1 Constant velocity motion

The objective of this experiment is to create constant velocity. Since there is always friction, the SmartTrack must be set at a very slight angle to compensate. If you get the angle right, the car will not move by itself, but will roll downhill with constant velocity if given a small push. You don't need the car to move very fast—any velocity between about 5 and 20 cm/s works just fine.



1. Set up the SmartTrack with two feet as shown in the diagram and connect the distance-velocity sensor to the DataCollector.
2. Select meter mode. You should see a measurement screen that shows you position (d) and velocity (v) with a stopwatch for time at the bottom. Set the units to cm.
3. Place thin objects under the free end of the track to provide a small slope. The slope should not cause the car to roll by itself, but the car should *keep* rolling if started with a small push.
4. Push the car down and let it roll freely while watching the velocity measurements. Your goal is to make the velocity as constant as you can. Adjust the angle in small increments by adding or subtracting shims under the end of the track. Record three trials of your best set-up.

Table 1: Velocity and Acceleration Data

Velocity (cm/s)	

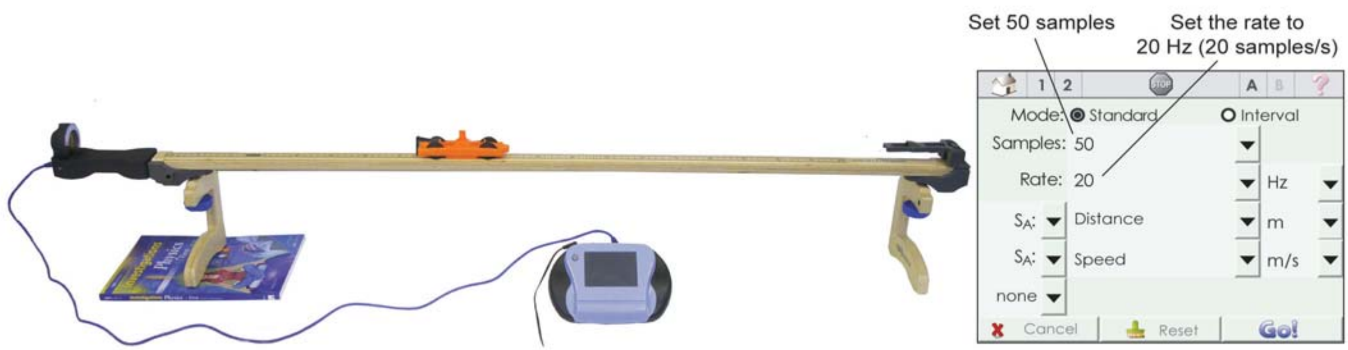
2 Thinking about what you observed

a. Why did the track require a slight downhill angle to make constant velocity?

b. What is the acceleration if the velocity is exactly constant?

c. When do you expect the acceleration to be positive? negative? zero?

3 The graph of constant velocity motion



1. Select data collection mode from the home screen, then tap setup and set samples to 50 and the rate to 20 Hz.
2. Put the car at the start of the track, press the go button, and give the car a small push after the countdown. The DataCollector will begin taking data after the countdown. The initial view of the data is the meter view, which shows just the single (i.e. live) data value for each input.

4 Analyzing the data

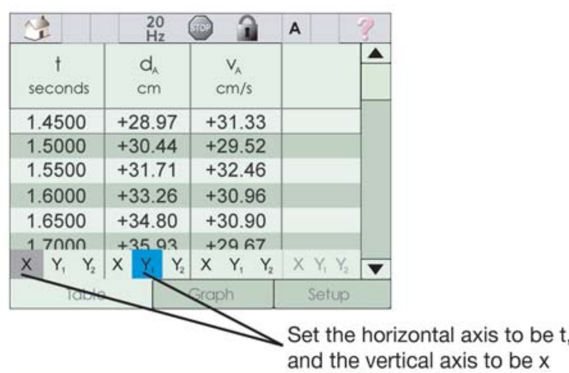
a. Once the DataCollector takes the samples, switch to table view, by tapping the Table tab. You should be able to scroll through the position (*d*) and velocity (*v*) data.

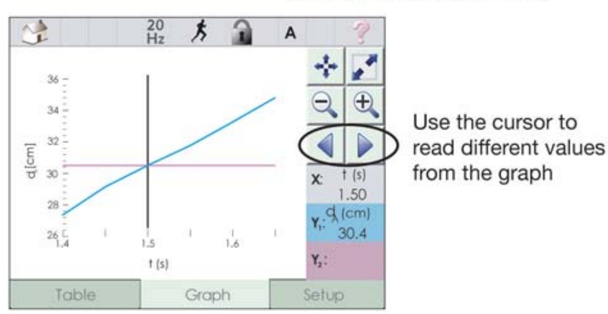
b. Set the time (*t*) column to be X and set the position (*d*) column to be Y1. Make sure to deselect Y2. Switch to graph view.

c. Describe the graph you see. Is it a straight line or a curve?

d. 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 position and time at two separate points.

e. Rewrite the equation for a straight line using the following variables: position, d; initial position, d_0; velocity, v; and time, t.





f. Compare the velocity you derive from the slope of the line in part d with the velocity you measured on the SmartTrack. Are the two values similar? By what percentage are they different? Give a possible explanation for any differences.