4.2 Accelerated Motion

How does acceleration relate to velocity?

A model for uniformly-accelerated motion includes velocity, acceleration, position, and time.

In this investigation, you will:

- determine an equation for the velocity in accelerated motion.
- use the equation to make predictions.

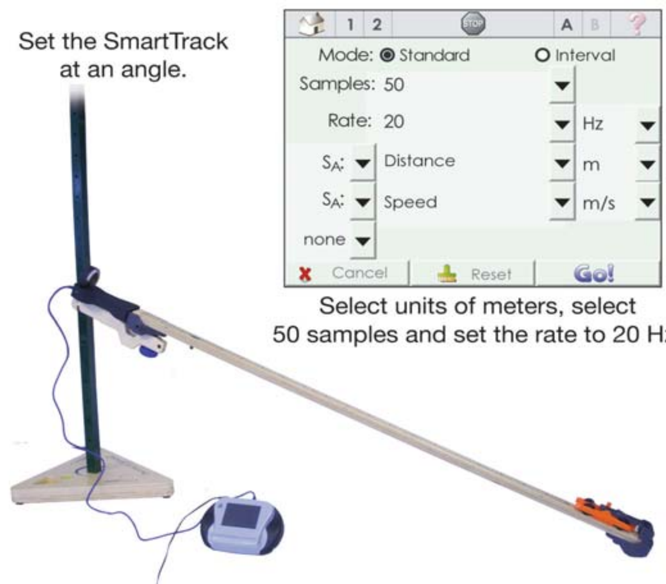
Materials List

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

1 Uniformly accelerated motion

1. Set up the SmartTrack at an angle by attaching it to the stand at the 5th hole from the bottom of the stand.
2. Set the DataCollector to data collection mode from the home screen and use the setup tab to set the samples to 50 and the rate to 20 Hz.
3. Put the car at the top of the track, and tap the go button. The DataCollector will begin a short countdown and then will begin taking data. The initial display is the meter view of the data where you should see time, position, and velocity.
4. Release the hold button on the SmartTrack to let the car roll down the track.

Set the SmartTrack at an angle.



Select units of meters, select 50 samples and set the rate to 20 Hz.

2 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 data.

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. 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. Try using data points that fall within the 5 to 30 cm distance down the track.

e. Rewrite the equation for a straight line using the following variables: velocity, v; initial velocity, $v0$; acceleration, a; and time, t.

f. Calculate the slope of two points between from 30 to 55cm down the track. Compare the acceleration you derive from the slope of the line at this part of the track with the acceleration you derived in part d above. Are the two values similar? By what percentage are they different? Give a possible explanation for any differences.

3 Testing the equation

The equations for uniformly accelerated motion are

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

a. Assume that the initial position, x_0, is zero. This is true if the position is measured from the flag of the car just before it starts rolling down the track, which is something you will see in the next part of the investigation. Assume also that the initial velocity, v_0, is zero. Rewrite these two equations eliminating terms that are zero.

b. To predict the velocity of the car at any point on the track, we need a formula that relates *velocity* to *position* and *acceleration*. We have a formula that relates position to acceleration and time, and another formula that relates velocity to acceleration and time. We need to combine these to eliminate the variable of *time*. Solve the position equation for time so you have an equation of the form: $t = ?$.

c. Substitute this value of t into the velocity equation and solve it to get an equation of the form: $v = ?$ where only the variables x and a appear on the right hand side. You will need to use the following algebra technique for bringing a fraction into a square root.

$$a\sqrt{\frac{b}{a}} = \sqrt{a^2}\sqrt{\frac{b}{a}} = \sqrt{\frac{a^2 b}{a}} = \sqrt{ab}$$

4 Testing the equation

1. Attach one photogate to input A of the DataCollector and select timer mode.
2. Using the same track setup as in section 1, place the photogate somewhere on the track and measure its position as shown in the diagram.
3. Use the position, x, you just measured, and the value of acceleration, a, to calculate the velocity the car should have when it reaches the photogate.
4. Use the relationship $t = d/v$ to calculate how long it should take the flag on the car to break the light beam. The d in this formula is the width of the flag on the car, which is 0.01 meters (1 cm).
5. Let the car roll down the track and see how close your prediction comes to the actual measured time interval.
6. Calculate the percent error between your prediction and the measurement. Take a few trials to get a sense of the accuracy of the experiment is.