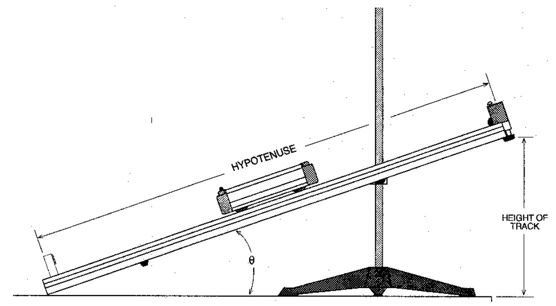
Constant Acceleration and Excel Graphing

In this lab we consider an example of kinematics in one dimension, involving a cart moving with constant acceleration. We hope to find the acceleration from measurements of distance and time. We use one of the equations of constant acceleration as a hypothesis.

If the acceleration is constant, the following mathematical relationship holds

$$\Delta x = v_0 t \; + \tfrac{1}{2}\, a\, t^2 \,,$$



where Δx is the displacement down the incline, v_0 is the initial velocity, a is the acceleration, and t is the elapsed time.

If the cart is released from rest, then $v_0 = 0\ m/s$, and we can write this equation as:

$$\Delta x = \frac{1}{2} a\, t^2$$

Applying the Scientific Method: We'll think of this equation as our hypothesis. Then, we'll take data to test it. If the data don't match the hypothesis, we need to modify the hypothesis. If the data do match this hypothesis equation, we'll be able to extract the value of the acceleration a from our analysis.

Experimental Procedure

Check that the wheels of the cart are running smoothly. Remove any dirt from the track. Put the cart on its side when not in use so that it does not roll off the table.

Release the cart from rest at the same starting point each time. For each run, line up the front of the cart with a point near the top of the track (20cm, say). Start the clock at precisely the moment you release the cart. Make sure you don't push the cart as you release it, because it must start from rest.

Stop watch: For each run, bring your eye to the end position as the car travels, and stop the clock exactly as the front of the cart passes that point. Practice this a few times before recording any data to get used to the action needed to do this carefully.

Times: Take three times for each distance, and handwrite each one on a hard copy of the table. Don't fill them directly into Excel because it's too easy to lose data that way. Your times for each distance will have some natural variations, but the biggest and smallest should be well within half a second of each other.

Distances: Your track should be either about 110cm or 210 cm long with the zero at the upper end. (If the numbers decrease downwards, modify the following accordingly)
<u>110cm track:</u> start each cart run with the leading end at $x_0 = 20$ cm. Measure times for final positions at $x = 110$cm, 100cm, 90cm, 80cm, 70cm, 60cm, 50cm, 45cm, 40cm, and 35 cm.
<u>210cm track:</u> start each cart run with the leading end at $x_0 = 30$ cm. Choose the first five final points to be $x = 210$cm, 190cm, 170cm, 150cm, and 130 cm. Then let the remaining five points go in 10cm steps: 120cm, 110cm, 100cm, 90cm, 80cm.

Significant digits: You should record every digit that appears on any *measuring* device. So, record the times exactly as they appear on the stop watch. (It's different when you *calculate* quantities with your calculator or spreadsheet, since this produces recurring decimals that have no significance beyond the number of measured digits. In these cases, it is your responsibility to provide the logical number of significant digits.) For distance measurements, the position of the cart is accurate to the nearest millimeter, so you should show one decimal in all the centimeter readings. For example: 20.0 cm is correct, not 20 cm.

Data Table: Write your data in this table in hard copy to ensure you don't lose them. When you make your Excel table, you'll need all the columns shown. The shaded ones are calculated columns that should be filled with the software.

x_0 (cm)	x (cm)	$\lvert\Delta x\rvert$ (cm)	t_1 (sec)	t_2 (sec)	t_3 (sec)	t (sec)	t^2 (sec^2)	$\Delta x^{0.5}$ ($cm^{0.5}$)

Graphs and Analysis:
The analysis is similar to what was done in the linear graphing lab. Your instructor will explain the analysis and what you have to turn in:

Make sure you turn in the items in the following list. Staple your pages together, with the cover page on top. Units must be used properly in your calculation and answers. Write out your work neatly in the spaces provided on that cover page. Provide both acceleration values to two significant digits.

a. Data table, with all the columns shown above. Use the Excel guidelines for this and the following.

b. Graph of displacement versus time

c. Graph of displacement versus time squared. Since this one should be a direct proportionality, it is consistent with the hypothesis equation and you can find the acceleration using the linear trendline. Show the trendline equation and ensure that the slope has three significant digits.

d. Graph of the square root of the displacement, $(\Delta x)^{0.5}$, versus time. This should also be consistent with a direct proportionality. So, select the linear fit, show the trendline equation, and ensure that the slope has three significant digits.

e. At the bottom of the cover page: check the acceleration using $a = g\ sin\theta$, with $g = 981\ cm\ s^{-2}$. Figure out the angle θ by taking measurements as shown on the diagram. If they differ by more than 5 degrees, consider whether you've erred somewhere.

Constant Acceleration Lab Cover Page

Day: T W R Time: _____ Name: _________________

Partner: _____________

Part (c) Analysis for Δx versus t^2:
Slope read from trendline equation (with unit) =

Use this slope to find the acceleration. Show your work clearly:

Part (d) Analysis for $\Delta x^{0.5}$ versus t:
Slope read from trendline equation (with unit) =

Use this slope to find the acceleration. Show your work clearly:

Part (e) Direct calculation of acceleration:
On a simple diagram, show the measurements taken, then show the trigonometry to find θ. Use that angle to calculate the acceleration from $a = g \sin\theta$. Show your work clearly: