

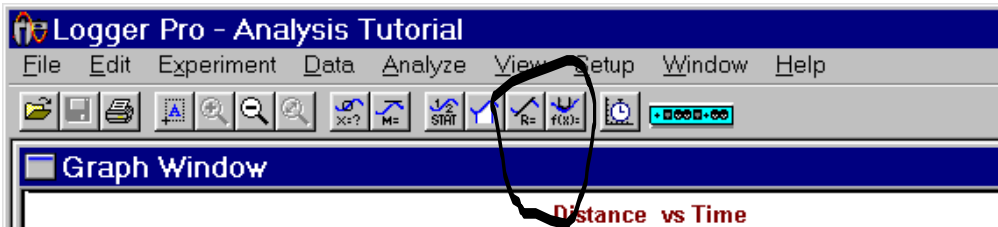
Analysis of data using LoggerPro Pre-Lab

Start LoggerPro. If LoggerPro asks for the interface, simply click the cancel button. Open the sample data file by going to the file->**import** menu item and selecting the file n” from the dialog box. The file should be stored in the “My Network Places - SharedDocs on Physics20/LoggerPro data.” Select the data file you have been assigned. *Note: when you go to SharedDocs, you may need to wait a while for physics20 to appear. Be patient!* Once you open this file you will be presented with a set of sample position data and a position – time graph. You should create velocity and acceleration data columns. Please record the data number displayed at the top of the graph window.

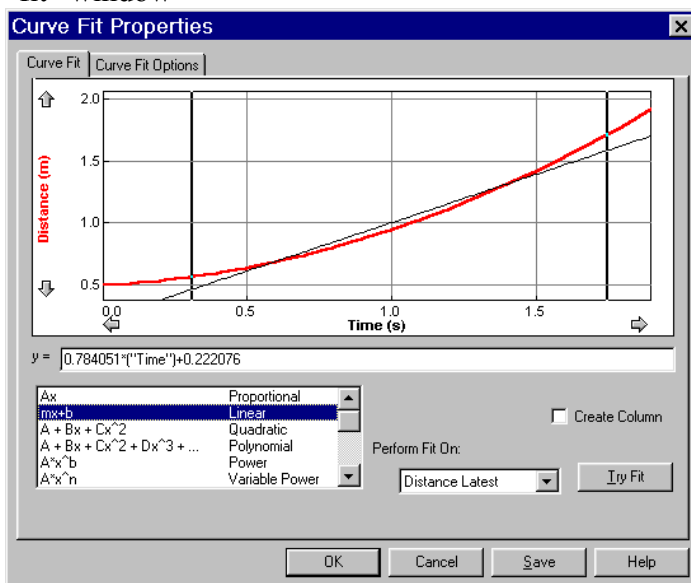
Data number:

Position analysis: Right click the mouse at one end of the region of interest on the graph (i.e. where the cart was moving) and then drag the mouse to the end of the region of interest (just before the cart stops). This selects the set of data that will be fit by the fitting routines. When you select a region of interest on one graph, it selects the same region for all of the data sets (i.e. if you select a region of interest for the position – time data, then the same region is selected for the velocity and acceleration data).

There are two buttons on the menu bar for curve fitting: the one on the left (a line with R=) is for “linear regression.” The button on the right (with f(X)=) is for functional fits. The latter is a more general system that includes linear, polynomial, logarithmic, exponential, power, etc. If your data looks linear, then it might be reasonable to use a linear fit. If it does not, then perhaps a more complex function should be used. One must get used to the idea that rapid variations are often noise and the best-fit curve goes through the center of this noise.



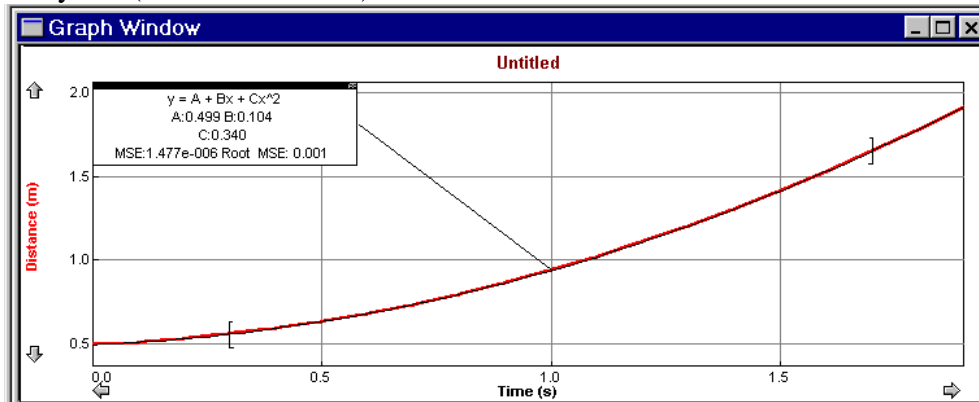
Select a region of interest in the distance vs. time window and then press the “curve fit button.” This opens a “fit” window



Choose a function such as say “Linear” and then click “Try Fit.” This will show the fitted curve (a line in this instance) in Black overlaying your data. Notice that this is not a stellar fit to the data.

1. **Explain fully and precisely why this fit would be rejected.**

Next try a “Quadratic” fit. If this looks appropriate, then click “OK” and continue. The graph will now show the fit parameters (A, B and C). These quantities have meaning that can be partly discerned by dimensional analysis. (*You should do so*).

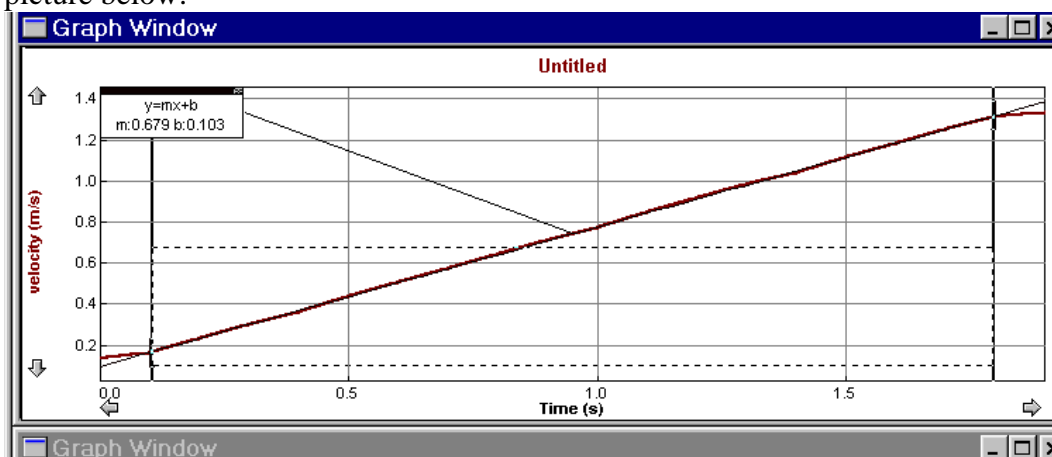


In the example above: A has a value of 0.499, B has a value of 0.104, and C has a value of 0.340, with units of _____, _____, and _____ respectively. A has a value of 0.499 with units of _____ which means it is a _____ (physical quantity). B has a value of 0.104 with units of _____ which means it is a _____ (physical quantity). C has a value of 0.340 with units of _____ which means it is a _____ (physical quantity).

Your values will differ. Record them in the table.

A=	
B=	
C=	

When we perform similar types of fits on the velocity and acceleration curves, we must be aware that this data is calculated from the distance data. Any errors in the distance data gets magnified in the velocity data and even more so in the acceleration data. Furthermore, the leading and trailing data points of the velocity and the acceleration data are invalid because they average in zero or constant values for the initial and final data points in the smoothing function. These data points are actually outside of our interval of interest. The duration (in time) of this invalid data can be decreased by increasing the sampling rate. Regardless, upon examination of the velocity - time graph, we found that we could use a linear fit. Doing so, we arrive at the picture below:



Notice the regions at the beginning and end of the data that are flat. These regions are an artifact of the way LoggerPro calculates the velocity (when using the smooth function in the velocity definition) and are therefore excluded from the fit. This graph contains a fit line with a slope of 0.679 and an intercept of 0.103 (Again, your values will differ). These quantities also have units and by dimensional analysis we are able to compare them with the quantities determined by fitting the distance – time data. The appropriate units for the example above are 0.679 _____ and 0.103 _____.

Your value for the slope is _____ with units of _____ which means it is a _____. Your value for the intercept is _____ with units of _____ which means it is a _____.

Having completed this analysis for your initial run you should compare all of the constants that have been determined by your measurements – in particular look for relationships between constants with the same units. If we have completed the dimensional analysis we find that the slope of the velocity – time was 0.679 m/s^2 . From the position – time data, we used a quadratic fit and the value of the C coefficient (the value multiplying time squared) was 0.340 m/s^2 . Hmm, how interesting that this value is $\frac{1}{2}$ of that measured from our analysis of the acceleration and the velocity. What you have done is measured the same quantities in several different ways. Recall from kinematics: $x(t) = x_0 + v_0t + \frac{1}{2}at^2$, where x_0 is the position at $t = 0$, v_0 is the velocity at $t=0$, and a is the acceleration. The quadratic equation we fit to the data was listed as: $y(x) = A + Bx + Cx^2$. Note: in the first case we used “t” as a variable while in the second we used “x” as a variable. By direct comparison of these two equations we can determine the meaning of the three “fitting” parameters A, B and C.

$$x(t) = x_0 + v_0t + \frac{1}{2}at^2 \quad (1)$$

$$y(x) = A + Bx + Cx^2 \quad (2)$$

Clearly, A must be the same as x_0 . In equation (1), v_0 multiplies the independent variable “t”. In equation (2), B multiplies the independent variable “x”. Therefore, B must be v_0 . Finally, in equation (2), C multiplies “ x^2 ”, while in equation (1) $\frac{1}{2}a$ multiplies “ t^2 ”. Therefore C is equivalent to $\frac{1}{2}a$.

From this we can see that to determine the acceleration from the position - time graph we must multiply the “C” coefficient by 2. If we do so, it then compares favorably with that calculated from the velocity – time graph and the acceleration – time graph (position – time value: $a = 0.680 \text{ m/s}^2$, velocity – time value: $a = 0.679 \text{ m/s}^2$, and acceleration – time value: $a = 0.691 \text{ m/s}^2$). Since the slope was meaningless in the acceleration – time graph, it might have been preferable to just use the “statistics” calculation to calculate the mean value of the acceleration over the interval of interest. This results in an acceleration of 0.681 m/s^2 .