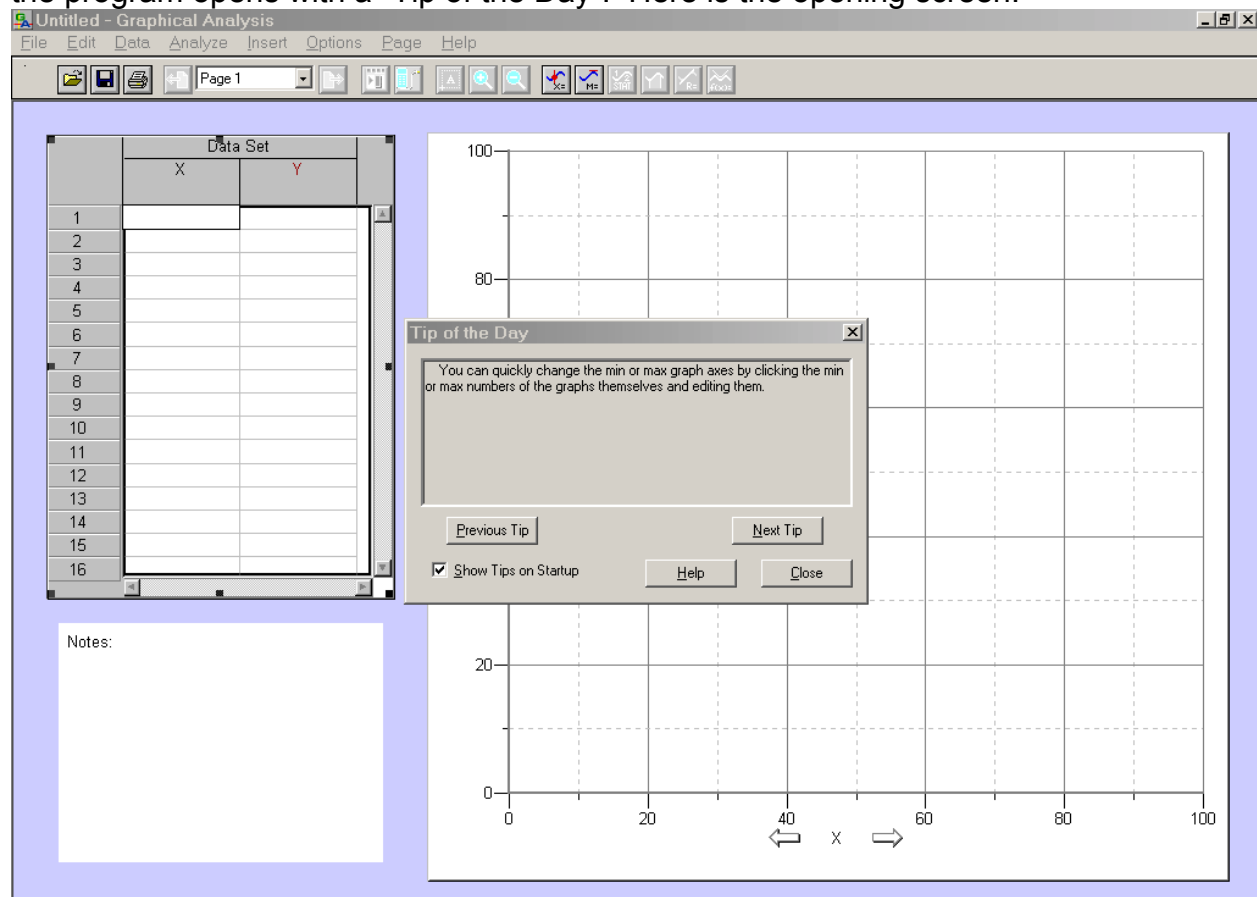


Lesson 00-F-Graphical Analysis I

Graphical Analysis, by Vernier Software, is a program that you will use frequently this year. **Graphical Analysis** makes it easy to create graphs of your data. More importantly, it includes tools that will find the best equation to fit the data. It will not tell you which form the equation should take. That we will get from theory. However, once the proper form of equation is known, **Graphical Analysis** will find the best coefficients for that equation to fit your data.

First, we'll learn to make a basic graph. That's very easy. Then we'll learn how to dress it up with labels on the axis and a title for the graph. Finally, we'll discuss the process of fitting the data to an equation and what to do with the coefficients that **Graphical Analysis** provides. **Graphical Analysis** has many features, but these are the basic operations we need most often.

Starting **Graphical Analysis**. After you double click on the icon in your physics folder the program opens with a "Tip of the Day". Here is the opening screen.



The "Tip of the Day" might be useful to you over the long run. Whether you read it or not, click on the **CLOSE** button to get started with **Graphical Analysis**.

If you have data ready to graph all you need to do is type it into the x and y columns. Make sure you enter the data for the horizontal axis in the x column and the data for the vertical axis in the y column. The clue to which is which is indicated by the name of the graph you are instructed to create.

Graph names take the following general form. This form must be adhered to whether you are creating a graph required for a lab assignment or creating and naming your own graph. The general form is y-axis vs x-axis. Thus, a graph of Pressure vs Altitude is a graph where the pressure data is graphed vertically and the altitude data is graphed horizontally. In laboratory exercises the order is dictated by the theoretical relationship between the x and y variables, but the naming rule still applies.

Creating a Basic Graph – To get started, the table below includes two columns with your x and y values. Enter the data into the correct columns of **Graphical Analysis** to create a graph of y vs x.

x	y
0	-3
1	-5
2	-3
3	+3
4	+13
5	+27

As you enter the numbers hit the **ENTER** key after each number. The pointer will move across from left-to-right and then at the end of a row it will move to the beginning of the next row below. By default **Graphical Analysis** puts point protectors at each point and adds connecting lines between the points in the order they appear in the data table.

Your first task whenever you create a new graph is getting rid of the connecting lines. We do not accept graphs with connecting lines. The only lines allowed on your graphs are lines that fit the data points to an appropriate theoretical equation. To turn off connecting lines click through the following sequence. Begin by clicking anywhere on the graph to make it the active window. The black outline highlights the active window. Then on the menu click

OPTIONS – GRAPH OPTIONS – uncheck CONNECTING LINES – OK

The connecting lines should disappear leaving only the point protectors around each data point.

These data points lie along a parabolic curve. Your task is to find the parabola that best describes this data. Before you try that, however, look carefully at this graph. What is missing? The names x and y are not very informative. There is no title. Your name is not on the graph so there is no way to know who created it. There is no information to indicate in which laboratory experiment the data was measured.

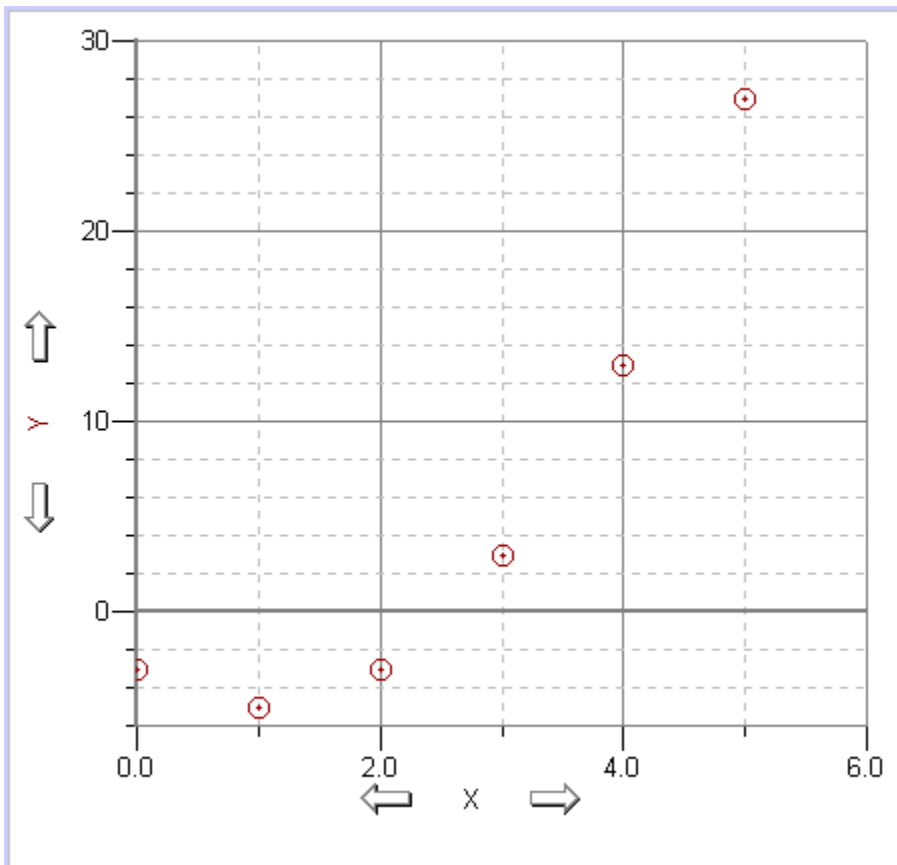
One good thing the program has done on its own is to adjust the axes so that all the data points are on the screen. This is called auto-sizing. It is the default.

Settings for Untitled Under the File menu select Settings for Untitled. If you are going to use angles in any calculations decide now if you will use degrees or radians in all calculations. Radians are the default choice. If you will use degrees select that button.

Saving the Graph – Save the graph early and often. This is a good time to save it. Do not get lax about saving. If the electricity goes off, or you later discover an error in the printed graph, you will want access to the saved graph. If you do not save, then the only option will be to recreate the graph from scratch. At home you may save it anywhere you like. At school, it must be saved in your personal Documents folder. Make sure you know how to access this folder. We will cover it in the Computer Lab. We will also discuss how you can obtain your own personal copy of the program CD.

Save it now and save it again after making any important changes or adjustments. Of course, save it again just before you make the final printout.

Dressing up the Graph – This is not merely decoration. Identifying the creator of the graph and the source of the data are essential. An unlabeled graph is so much scrap paper. The graph at this stage looks like this:



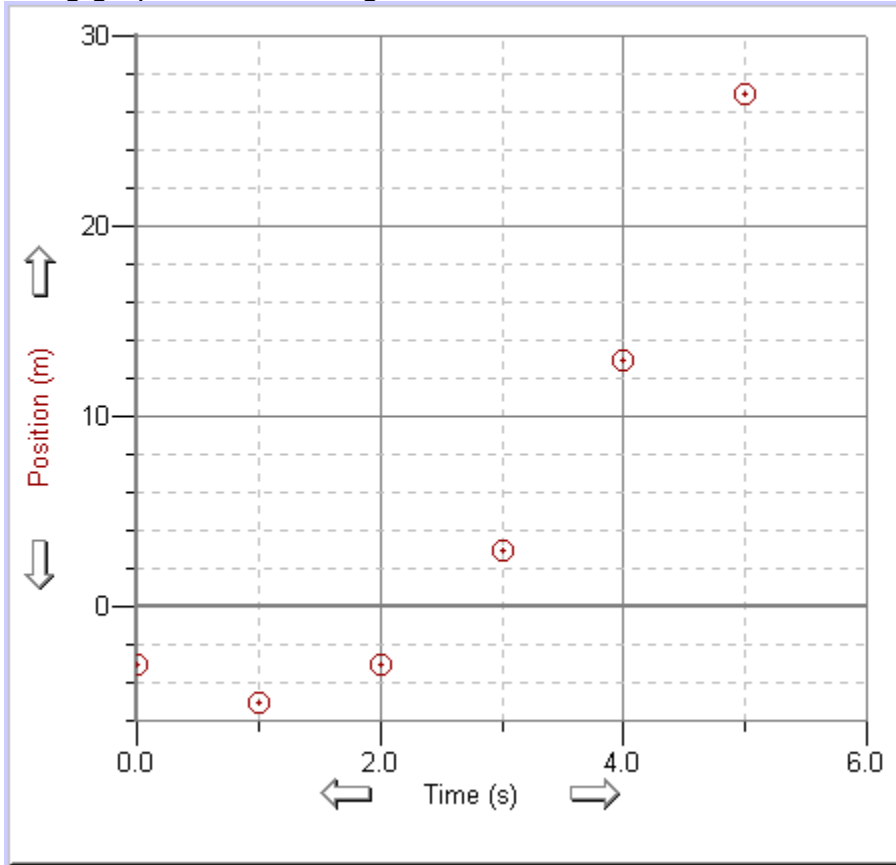
Nice graph, but what is it? Let's begin with the axes' labels.

The x-axis is really time measured in seconds. To change it to time, click on the label at the top of the x column in the data table. A window pops up where you should enter time as the name and s, for seconds, as the units. For the short name enter the letter t. Then click on OK.

Click on the label at the top of the y column in the table. For the name enter Position. For the

short name use x. For units enter m, for meters.

Here is the updated graph with its axes properly labeled. Now that we know what is being graphed it is starting to make more sense.



If you trace the data points with your finger you can probably figure out that these points lie along a parabolic curve. That would be a good guess at the very least. If we were testing one of the equations of physics, it would dictate the form of equation to test.

The next step is to get **Graphical Analysis** to draw the best parabola that passes through or near these data points. We will not discuss the mathematics behind the method used by

the program in detail. Nevertheless, it is worth knowing a couple of basic things about this method.

It operates on the assumption that there is no error in the x-values; that the left-right position of the points is precisely known. It assumes that all the error in the data points is in their vertical positions. The program then finds the parabola that comes closest to all the data points by minimizing the sum of the squared vertical distances between the points and the line. Once it completes this so-called least-squares fit to the data, it Draws the graph and prints the results in a box on the graph.

Preferences – From the main menu click on **FILE – PREFERENCES**. Make sure the following boxes are **NOT** checked.

Display Larger Text on Screen
Thick Graph Trace Lines

Other boxes on the preference screen should have check marks in them. Click **OK**.

Finding the Parabola with the Best Least-Squares Fit to the Data

The general form of a parabola is

$$y = ax^2 + bx + c$$

In the specific case of the position equation, It has the following theoretical form;

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

Graphical Analysis can provide us with the coefficients a, b and c of the best parabola for our data. All we will have to do is convert these to

$a = \frac{1}{2}a_t$ ($\frac{1}{2}$ the acceleration), $b = v_0$ (the initial velocity), and $c = x_0$ (the initial position).

Since the data does fit a parabolic curve, we can be assured that the conversions are valid;

$$a_t = 2a; \quad v_0 = b; \quad x_0 = c$$

Therefore, by finding the best parabolic equation through the data, **Graphical Analysis** enables us to find the acceleration, the initial velocity and the initial position. Some of these we may have measured and some, perhaps, may only be found from the best-fit equation. Either way, finding the coefficients of the equation, which is otherwise, a very difficult process, is easy thanks to the help provided by **Graphical Analysis**.

You do not even need to type in the general form of this equation because **Graphical Analysis** provides most of the common forms for you. Later in the course you will learn to create new equation forms for yourself.

To find the best parabola through this data, click through the following steps.

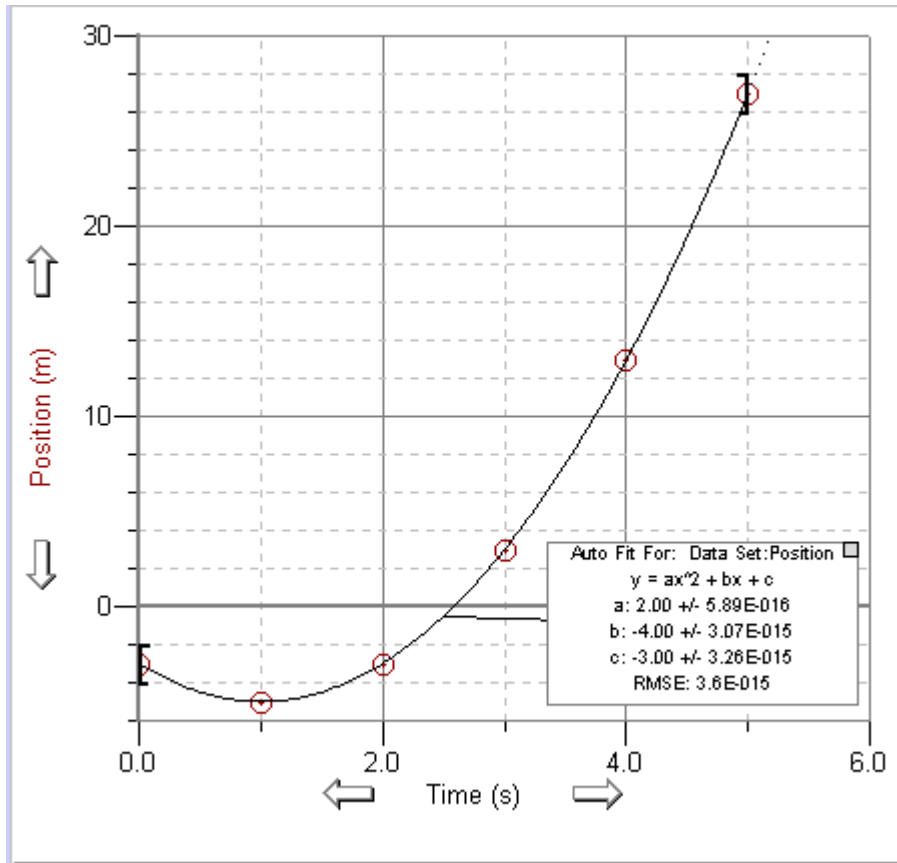
Click on the graph, if necessary, to make it the active window on the screen. Then,

ANALYZE – CURVE FIT – click on (QUADRATIC) – TRY FIT – OK

A box with the general form of the equation and the coefficients will appear on the graph. Click, hold, and slide the box around so it does not cover any of the data points or any part of the curve.

Other items that appear in the box are related to calculated errors. We are not going to use them so don't worry about them. We have our own methods of estimating the errors in the data.

Your Graph should now look like this.



The coefficients tell us that the equation describing the motion. It is

$$x = 2t^2 - 4t - 3$$

From the interpretation of the coefficients discussed above we now know that

$$a_t = 2a = +4 \text{ m/s}^2$$

$$v_0 = b = -4 \text{ m/s}$$

$$x_0 = c = -3 \text{ m}$$

There is just one more item to add to the graph. That is a title to include the lab number, that graph name and your name. The graph title must include the following information in the following order.

Lab Number – Graph Name - Your Name

For example

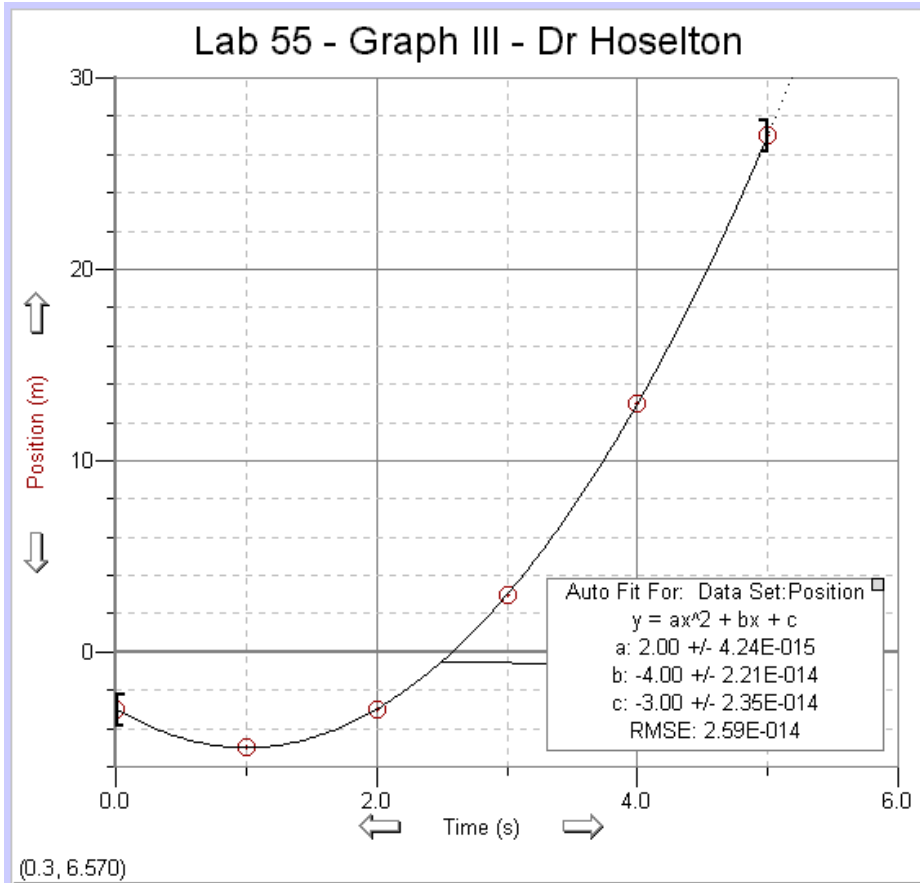
Lab 55 – Graph III – Dr. Hoselton

To add the title, click on the graph to make it the active window. Select from the main menu

Options – Graph Options

Type your title in the title box then click on the OK button. The title must fit on one line. The same information should also be placed in the text box in the lower left-hand corner of the screen along with the names of your lab partners.

Here is the finished graph showing the data, data fit and proper labeling.



This is the basic style for all the graphs in your lab assignments.

Many other options are available. If you must play with them, do not make the graph so complex that it is difficult to find the essential features shown here. If you want to play with changing colors or other features, check to ensure that the chosen colors and features have enough contrast to be easily read when printed on black and white printer.