

## How to Make Really Nice Graphs Using Microsoft Excel

### **Data Entry:**

Enter your data into Excel in column form such as the following:

Horizontal Variable Name	Uncertainties	Vertical Variable Name	Uncertainties
$x_1$	$\Delta x_1$	$y_1$	$\Delta y_1$
$x_2$	$\Delta x_2$	$y_2$	$\Delta y_2$
$x_3$	$\Delta x_3$	$y_3$	$\Delta y_3$
$x_4$	$\Delta x_4$	$y_4$	$\Delta y_4$
$x_5$	$\Delta x_5$	$y_5$	$\Delta y_5$
$x_6$	$\Delta x_6$	$y_6$	$\Delta y_6$

For example, if you are measuring the length of a spring under the application of a force, the table might look like this:

Position (m)	$\Delta$ Position (m)	Force (N)	$\Delta$ Force (N)
0.595	0.001	0.49	0.02
0.612	0.001	0.98	0.04
0.631	0.001	1.47	0.05
0.649	0.001	1.96	0.06
0.667	0.001	2.45	0.06
0.686	0.001	2.94	0.08

Make sure you have used proper units in the table so that the results will also come out in proper units. If the units need changing, there is no need to re-enter the data. Use Excel to do the work for you. Once you have the data in proper form for graphing, go on to the next step.

### **Creating the initial Graph:**

Click on the Chart Wizard icon (or select "Chart" on the "Insert" menu). From the graph types presented, select "XY(Scatter)" with no lines connecting data points and click "Next". The Wizard will present you with the Chart Source Data window. Select the "Series" tab in this window. Under the empty list of Series box, click on "Add". Now you need to specify the cells that contain the "X" values of your data points and which cells contain the "Y" values. Click on the small box with a triangular arrangement of lines on it that is located just to the right of the text box for X-values. The Source Data window will collapse and the program is waiting for you to indicate the range of cells containing the "X" values. Using the cursor, select the entire set of X values by first locating the cursor over the first X value and then holding down the mouse button while dragging over the remaining X values. When the correct cells are highlighted, release the mouse and click on the small box with the triangular arrangement of lines on it. The Source Data window will return to full size. Then click on the small box with a triangular arrangement of lines on it that is located just to the right of the text box for Y-values and select the Y data in the same sequence of step you used for X.

When you have completed defining the data series, select "Next".

In the next window, click on the "Titles" tab. Enter the correct title and axis labels for the graph. Click on "Axes". Both "X" and "Y" should be turned on. Click on the "Gridlines" tab and turn on both the major and minor gridlines for both axes. Click on the "Legend" tab. If you have only one set of data points to go on the graph (i.e. for each value of "x", there is only one value of "y"), then turn off "Show Legend". Click on

“Data Labels” and choose “None”. Click “Next” when done setting all the options in this Chart Wizard window.

The next window asks whether to put the graph in the current spreadsheet or in a new one. For maximum organization, it’s probably best to put each graph in its own sheet. (They print out much nicer that way.) Select “As new sheet” and click “Finish”. The graph appears. Don’t worry yet about its size or how ugly it is. You will be able to make it pretty and Excel will resize it to fill the piece of paper when you print it.

Double-click on the tab of the sheet that contains your data. (The sheet tabs are along the left side of the bottom edge of the spreadsheet window.) This allows you to rename the sheet “Data”. Then return to the sheet containing your graph.

### **Formatting the Axes:**

Format the x-axis of your graph as follows.

If the x-axis range or grid spacing are not appropriate for your data, change them. To do so, select the axis by moving the cursor over the axis and clicking the mouse button once. Then the first menu item under the “Format” menu becomes “Selected Axis . . .”. (Just double-clicking on the x-axis will also get you to this window.) Select the “Selected Axis . . .” item under the “Format” menu and you get a window with four tabs. Under the “Patterns” tab, select “Custom” Axis and make its color black. The major tickmark type should be “Outside” so that they will be clearly discernable when the gridlines are on. The minor tickmarks are not needed when gridlines are on but this is where you would control them if the need arises.

Select the “Scale” tab. Uncheck all the auto boxes. Pick the minimum and maximum values for your axis to suit your data values. Stick to fairly round numbers that begin slightly below your smallest data value and end just above your largest data value. The “Major unit” will be the spacing between *numerically-labeled* gridlines. The “Minor unit” is the interval size between adjacent gridlines. Find a nice medium between too many and too few gridlines. (Five to six major units on each axis and four or five minor units for every major unit usually make for a pleasant looking graph.)

Select the “Font” tab. Deselect “Auto scale”. Then set the font to your style of choice and a size of 10 or 12 point.

Select the “Number” tab. Choose the “Number” category and set the number of decimal places for the values that will identify the major tickmarks. Click “OK” to close the “Format Axis” window.

Repeat this formatting for the y-axis.

### **Altering the Graph Title and Axis Labels:**

If you need to alter the graph title or the axis labels, here’s how to do so. To edit or format the title, put the cursor over the title and click once. Then the first line under the “Format” menu becomes “Selected Chart Title”. (Just double-clicking on the title will also get you to this window.) Choose it and select the “Font” tab in the next window. Deselect “Auto scale” and set the font to your selected style. Use a font size at least two step larger than that used for the major tickmark labels. The title should probably also be in boldface.

If you need to edit the title, click on it again, after selecting the title. The cursor will appear in the text, ready to type in additional characters or to delete characters.

To edit or format the axis titles, put the cursor over the axis title and click once. Then the first line under the “Format” menu becomes “Selected Axis Title”. (Just double-clicking on the axis title will also get you to this window.) Choose it and select the “Font” tab in the next window. Deselect “Auto scale” and set the font to your selected style. Use a font size at least one step larger than that used for the major tickmark labels. The axis title should probably also be in boldface. (You might use 10-point font for the major tickmark labels, 12-point boldface for the axis titles, and 14-point boldface for the graph title.)

### **The Plot Area:**

The background area in the graph should be white. If it's not, select the Plot Area by clicking on the space between the gridlines. (If the gridlines are too close together, the program may keep selecting the gridlines instead. When this problem occurs, drag a corner of the graph window so as to enlarge the graph. This will spread out the gridlines so you can select the Plot Area. If you neglected to turn off all the "Auto scale" features, you will also notice that some of the text characters will get larger too. This can be very unsightly.) With "Plot Area" selected, the first item under the "Format" menu becomes "Selected Plot Area". (Just double-clicking on the area between gridlines will also get you to this window.) Choose this and change the border to "Custom" and make the color black. Change the Area to "None".

### **Data Markers and Error Bars:**

Now select the data series by clicking on one of the data points in the graph. When the series is selected, the first item under the "Format" menu becomes "Selected Data Series". (Yes, you can just double click!) Choose this and a window opens. Under the "Patterns" tab, select none for line. (Dot-to-dot connection of data points is generally not wanted.) For "Marker", change the background to "No Color" and select the shape wanted for your data points. Try the small "o" or "x" and see how it looks after the error bars are added. Choose a color for the marker (Foreground) and set the size. (3 or 4 point is often large enough; you don't want to obscure your error bars with a big data marker.)

Under the "X Error Bars" tab, select "Both" left and right portions of error bars. (This is correct whenever you have a single plus-or-minus uncertainty value. If you every have a plus uncertainty that is different from the minus uncertainty, then you need to enter and treat the two independently.) Click on "Custom" and enter the range of cells containing the uncertainties that accompany the data corresponding to the x-axis. (The easiest way to do this is to click the cursor into the range box and then use the cursor to select the range of cells. You will need to move back to the data sheet while doing this. Excel enters the cell address for you.) Be sure to do this for both the "+" and "-" range boxes.

It will sometimes happen in physics labs that all the X values or all the Y values have the same uncertainty or the same percentage uncertainty. When that happens, it's very convenient to use the "Fixed Value" or "Percentage" features. Select the appropriate one and enter the proper fixed value or percentage.

Under the "Y Error Bars" tab, repeat this for the y-data uncertainties.

Click "OK" in the "Format Data Series" window.

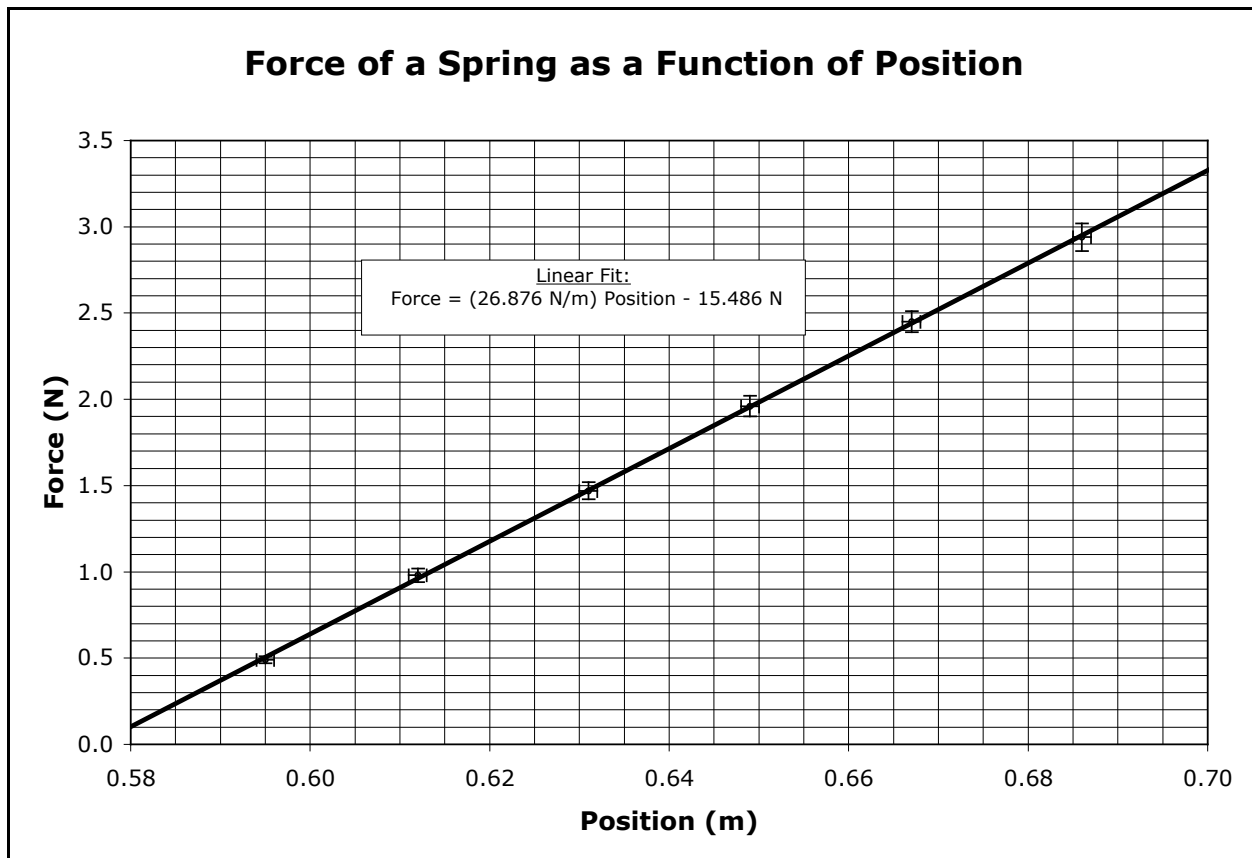
### **Linear Fit:**

If the data points appear to form a straight line or if you have theoretical reasons for believing the graph should show a linear relation, then a line can be fit to the data. Click on "Add Trendline" under the "Chart" menu. (You need to have the graph selected or you won't see this menu.) Under the "Type" tab, select "Linear". Select the "Options" tab. You may enter a trendline name now or put it in later. ("Linear Fit" would be a good name to start with.) Forecast 0.5 or 1 unit both forward and backwards for a pleasing look to your line. Check the box for "Display equation on chart". Click "OK".

The linear fit equation and the line showing it will appear on your graph. Select the equation and fix it up as follows. While the equation box is selected, the first line under the "Format" menu becomes "Selected Data Label". Chose this. Then under the "Patterns" tab, set "Border" to a black line and "Area" to white. Click "OK". Click the cursor into the equation text and substitute your actual variable names and put proper units on the slope and intercept values. (Don't leave the equations in terms of "x" and "y" unless those were the actual variable names associated with your data!) Move the equation box by dragging it with the mouse.

### Printing Your Graph:

When ready to print, select the graph. Look at it in "Print Preview". It should fill a single page and be a thing of beauty. If it meets your standards (and your instructor's) send it to the printer.



### Assignment: (Not assigned this year.)

Using the following data, create a graph consistent with the instructions in this handout. Insert your name into the graph title.

Position (m)	$\Delta$ Position (m)	Force (N)	$\Delta$ Force (N)
0.265	0.001	0.49	0.03
0.282	0.001	0.98	0.06
0.301	0.001	1.47	0.06
0.319	0.001	1.96	0.09
0.337	0.001	2.45	0.09
0.356	0.001	2.94	0.12