HOW TO PLOT SCIENCE GRAPHS

A guide to using Excel for scientific plots in Physics 359E

INTRODUCTION

The third year lab generates a large amount of scientific data that is best presented in the form of graphs. However, not everyone is familiar with the graphical tools available in the lab and on many computers elsewhere. This short note summarizes how to make simple data plots, and plots of algebraic functions – for example, fits to the data points – using Microsoft Excel. Excel is a part of the the Microsoft Office suite, and is available on the computers in the lab. If you have Microsoft Word on your computer, you probably also have Excel.

Creating a graph of a set of data points

Suppose you have a file on one of the lab computers that contains science data in the form of an $x - y$ table: two columns of numbers (or perhaps three if you have a column with measurement errors). The following recipe should enable you to produce a graph of these data which you can include in your lab report, either as a figure imported into the word processor file of your report, or as a stand-alone figure which you can simply print out and staple into your report.

- Create a link (a shortcut or icon) on your desktop to the data file. This can be done using the Windows Explorer: find the file in Explorer, right click on it, click on "Create Shortcut", and then drag the shortcut to the desktop. Iconify or close the Windows Explorer.
- Click on the file icon on your desktop and drag it to the Excel icon. Excel will open – with your file entered in the first two or three columns of the spreadsheet that Excel works with. (I don't know of any other way to get Excel to read in a text file, although there must be other methods.)
- If your data file is shown as columns with no vertical lines between the columns of data, Excel has decided that your data file is actually just a text file. It must be persuaded to treat the data as columns of numbers. Click on the "A" above the first column. This should highlight that column of numbers. Then go to the "Data" menu on the menu bar at the top, select "Text to columns", click twice on the "Next" button, and then on "Finish". Your data should now have vertical lines separating the columns of data.
- Each column has a letter header (A, B, etc) in a rectangle. Click on the label A and drag the cursor to the label B. Both columns should change colour from top to bottom. You have now selected these columns for graphing.
- In the second row of the menu bar at the top, click on the Chart Wizard button (it is a small group of coloured books towards the right end of the menu bar). A popup "Chart" (Microsoft's buzz word for "graph") window will open.

- Select "scatter chart" from the list of chart types. You can also select at this point one of several display types – data points, points joined by straight lines, etc. Then click on the "next" button, twice. In the third window, add your graph title, axis labels for x and y, and other desired labels. Again click on "next". (There are a number of possibly interesting choices to make in this popup. Experiment.)

- In the final window, choose "new sheet" for the graph type (otherwise it is embedded in your spreadsheet data file!). Click on "Finish" to finish the graph. It will be displayed in your Excel window, and you may edit it further by pointing at various parts and clicking. (Try it....)

- Click on the "File" menu button at the top, then on "Save as". Save the file somewhere with a name you will be able to find again ("lin.ls" might produce a table and graph "lin.xls" for example).

- Note that you can switch back and forth between the data table and the graph by using the tabs labeled "Chart 1" and "filename" at the bottom left of the window.

- This graph can now be imported into your word processor, copied to a diskette, or printed on a page using the Excel "Print" button.

- One problem with Excel is that it does not seem to be capable of plotting error bars included in your file (e.g. as a third column). It is only smart enough to plot error bars according to simple recipes (all the same size, proportional to the square root of the y value, etc).

Creating a graph of an algebraic function $y = y(x)$

Excel can also be used to create a graph of an algebraic expression, using a syntax very much like that used in Fortran (in fact, it is the syntax of Visual Basic, a programming language that you may have encountered previously). The following recipe will enable you to graph functions with Excel. You can use Excel to plot the values of a function at all the same x values as your experimental data, so that you can put both data and a fitting function into the same graph.

- Open Excel. If you have a data file in it, you can use the x values of the data to compute the values of the fitted function; otherwise, you will need to start by filling a column (say the "A" column) with a series of x values at which Excel will compute the y value of your expression. Let's suppose that you want to plot y at a series of x values increasing from 10 to 20 with steps of 0.5.

- If you need to create a list of x values, click on the top "A" box (called a cell), and type into it the first x value you want (say, 10). Next, click on the second "A" column cell, then click on the window following the "=" sign in the lower menu area. You are going to enter into this window a formula for calculating the value of x in the second "A" cell (which is called "A2") from the value in the first cell (called "A1"). Your formula would be written this way:

  $$= A1 + 0.5$$

  which tells Excel to compute the value for the cell A2 by taking the value in A1 and adding 0.5 to it. (N. B.: the initial "=" sign is essential.)

- Now you actually want to apply this equation to a whole series of cells; in each one the cell value will be equal to the value in the cell above, plus 0.5. This is done by clicking on the lower right corner of the cell A2 (the cursor will be a small "+" sign if you are in just the right spot for this operation). Drag the corner of cell A2 down as far as you need to in order to get the number of x values you want. The A column of cells will fill with values computed according to your recipe (10, 10.5, 11, 11.5,...). If you don't drag the corner to the right place on your first try, it can be moved up or down again.

- Next you need to fill a column with the y values corresponding to your x values in A. Click on the column you want to use (B, for example, or the first empty column if you already have data in the spreadsheet). Go back up to the equation writing box, and enter your expression, again couched in terms of how B1 (or D1, or E1, etc) should be computed from A1. Your equation might read, for example,

$$= 3.0 * \exp(-0.2 * A1) + 20$$

- Again click on the lower right corner of cell B1 (or whatever it is) and drag the corner down as far as your x values in A extend. Your B column will fill with values computed from your equation, in each cell (say B9) computed with the corresponding A cell value (say A9).

- You can now plot a graph of this function as before, or include it in a graph with your data plot by highlighting this column when you highlight your data columns for plotting. (If you have a column of uncertainties, you may have to delete it from the plot in the Chart popup in order to avoid having a curve showing the value of the uncertainty....)

- The same technique can be used to create a column of data with is the difference between your actual data and your fitting function – just create a new column, using the equation writer to fill the cells with values such as

$$= B1 - D1$$

There area a lot of small tricks that experienced Windows users will be able to use in this process, and which non-experienced users will gradually discover. Don't be discouraged if your first couple of tries don't quite succeed. Try again (perhaps from scratch).