

Numerical Calculations Using a Spreadsheet

Most problems in physics can't be solved in "closed form", that is, what you want on the left hand side of an equation equals some expression involving the important physical parameters on the right hand side. Having a closed form solution is great: it tells you how your result depends on various quantities, and you can see how each of the quantities individually affects your result. When a problem doesn't allow for a closed form solution, we usually can come up with a numerical solution, that is, for certain numerical values of the physical parameters our quantity of interest equals some number. This is clearly not as great, but.....it's better than nothing. In order to see how a result depends on a particular physical parameter, one usually plots the result versus the parameter to reveal the dependence graphically. This is an important method in the physical sciences, and we will be working on a series of problems this semester which will allow you to develop and practice your numerical calculation skills.

First, you need to locate a computer that you can work on, and one that has the Excel spreadsheet program on it. (There are other spreadsheet programs available; feel free to use a different one if you are comfortable with it. Other types of programs (Mathematica, Maple, Matlab, Mathcad, etc.) would also suffice, and sometimes might be preferable - you'll be learning them too in your time here. However, I ask that you work on these exercises using a spreadsheet program.

To get started, I suggest that you read this worksheet and just try to get a sense of what is going on. Bring up your spreadsheet of choice and wander around in it for awhile. Go over the menu items to see what is possible, check out the program help for unfamiliar functions, and talk with people already familiar with the program. Practice getting the program to generate columns of data determined by functions of your choice, and plotting your data. All of this will take awhile, and there is an incredible amount of stuff to locate and get familiar with, so you should be prepared to spend several hours at this, perhaps on several different occasions.

As an initial exercise, plot a quadratic, $x(t) = -5t^2 + 4t + 2$. Later you will be faced with more complicated task; this exercise is intended to be easy but will help you to become familiar with the spreadsheet program. The following discussion gives a run down of how to attack this problem using Microsoft Excel (other spreadsheet programs will differ only minimally). If you are already familiar with another spreadsheet, feel free to stick with it.

MICROSOFT EXCEL

There are a few things to know to get started:

- you can move around the worksheet using the arrow keys or the mouse
- to enter a number or a formula into a cell, select the cell by pointing at it with the mouse and clicking once, and then type in your entry
- when entering formulas you can use either lower case or upper case
- to make a menu choice point and click on your selection on the menu bar, and while holding the mouse down drag down to what you want and release

To copy a formula from one cell to others, you highlight the cell you want to copy (point at it and click), and then pull down 'Copy' from the 'Edit' menu. Then highlight the cell you want to copy it into, and pull down 'Paste' from the 'Edit' menu - it should now appear in the new cell. If you want to copy a formula or a number to a group of cells, you do it the same way except you need to highlight all of the cells you want to copy into. To do this, point at the first cell, and while the mouse is still down, drag over all the cells you want to highlight, and then let go of the mouse.

There is an important distinction between a relative address and an absolute address. What appears in a formula usually are constants, built in functions, and some numbers which are located in some other cells on the spreadsheet. When you copy a formula from one cell to another, sometimes you want to refer to a very specific spot, say the cell A4 (at the intersection of column A and row 4). To specify that you mean this exact spot, you give the absolute address as \$A\$4 (note the dollar signs). Sometimes a formula refers to a number in some cell at a particular relative location - say the adjacent cell on the left. For instance, we might have a formula in B4 which involves the number in A4. If I copy the formula to the cell in B5, I want the formula there to look for the number in A5. If I write the relative address A4 in the formula instead of the absolute address \$A\$4, copying into other cells will automatically give the correct relative address to use. (You can also give an address like \$A4, which is absolute in the column designation, but relative in the row designation). This is one of the very powerful features of spreadsheets, as you shall see. Play around and check out how it works.

To calculate and plot your quadratic function, fill in your spreadsheet in the following manner:

	A	B	C	D
1	-5	4	2	
2	0.25			
3	t	x		
4	0	= $\$A\$1*A4^2+\$B\$1*A4+\$C\1		
5	=A4+\$A\$2	copy cell B4		
6	copy A5	to these		
7	to these	cells		
...	cells			
15	down to here	down to here		

How is this stuff going to calculate our quadratic for us? Notice that A1 is -5 (the coefficient of the squared term in the formula), B1 is 4 (the coefficient of the linear term) and C1 is 2 (the constant term). Now look at cell A5. The equals sign that starts it tells the program to expect a mathematical formula. The formula means take the number in A4 and add to it the number in A2. Again, the use of A4 (no dollar signs) is a relative address, whereas \$A\$2 is an absolute address. See what happens to the formula as you copy the contents on A5 to the cells below.

So what have we got in column A? A sequence of numbers starting at zero, in quarter second intervals: this will be our time axis. Later on if we wanted to change it we could adjust cells A4, A2, and perhaps how far down in column A we choose to go.

How about B4? It says take the number in the cell to the left (A4 since we are in B4), square it (^2), multiply (*) by A1, add it to the product of B1 and the cell to the left, and finally add it to C1. When you copy this to the cells below the relative addresses will change, but the absolute addresses will remain the same. For example cell B6 should be: $\$A\$1*A6^2+\$B\$1*A6+\$C\1 . Move there and check (cell contents appear at top of screen).

Columns A and B, from rows 4 to 15, now contain the data we would like to plot - column A for the time t, in increments of 0.25 seconds, and column B for the value of the quadratic function at that time. How do we plot the data? Excel has a little routine called the 'Chartwizard' which lets you do it pretty simply. On the top of your screen under the menu bar there should be a toolbar, with a bunch of icons in it. If there isn't, choose 'Toolbars' in the 'Options' menu and click on 'Show'. Find the chartwizard icon and click on it to get it going. Now drag your mouse into the cell area of the spreadsheet, and instead of an arrow you should have a crosshair. (It tells you what

you need to do in the lower right corner). Click once to locate one corner of your new graph, and holding the mouse down move the crosshairs to the opposite corner and let up on the mouse. (Choose some area where your data isn't - you can always move your graph later). Now chart master gives you five choices to format your graph:

- choose the cells where your data is (A4..B15)
- choose the kind of graph you want (xy scatter)
- select a format for this kind of plot
- tell it whether your data is in columns or rows
- add labels if you like
- plot it!

If you have gotten this far, now you can see how things change for different quadratic functions. Move to cell A1 and change -5 to -10, or to whatever. Notice that the values in B4 to B15 changed by themselves. This is because the formula in those cells referred to $A1$ and you have changed A1. Notice also that the graph has changed, even rescaling the axes if necessary. Pretty slick, eh!? Try changing the values in B1 and C1, or A2, and see how your graph changes. Now that you can do this for a simple function, you can do it for any function that you can write out as an equation, (and even for some where you can't). Play around with it!