Computation and Computers in Geology

Spreadsheet Introduction and Exercises

Almost everybody has some knowledge of spreadsheets. That knowledge may be as limited as simply having seen a spreadsheet, done some basic data manipulation or used the spreadsheet for graphing. For these initial exercises I'll assume you can open Excel, know how to type values and labels into cells, and perhaps know how to cut and paste from cell to cell – if not you soon will. There are two main features in spreadsheet that I want to introduce in this initial set of exercises. Following a short discussion on these topics we'll work on some exercises.

I. Built in Functions

Modern spreadsheets have a huge number of built in mathematical and statistical functions that are useful in the Geosciences. Many structural problems involve trigonometric functions such as Sine, Cosine, Tangent and their inverses; these are all built into Excel (SIN, COS, TAN & ASIN, ACOS, ATAN). Excel, like almost any computer language, expects the arguments you give these functions to be expressed in radians, not degrees. The inverse functions return values in radians, not degrees. Excel conveniently includes functions (RADIANS, DEGREES) to convert between modes.

To find out what functions are available in Excel, follow these steps:

Click **Help**
- Click **Contents and Index**
  - Click the Index Tab
    - Type in "Functions" (or scroll down to "functions")
      - Double click "**functions**"
        - Double click "**about math and trigonometry functions**"

Of course you can use a similar procedure, or many variants, to get whatever information you need from Excel's help file – explore these on your own.

As an example, to use the SIN function type =sin(60) into a cell and hit the Enter key; the cell will display the value -.30481 because that's the sine of 60 radians. If you want the sine of 60^{o}, type =sin(radians(60)) so that you first convert 60^{o} to radians; the result will be 0.86602. The equal sign (you can use + instead) must precede any expression you want Excel to evaluate.

II. Relative versus Absolute Addresses

When you create a formula that references another cell, references to that cell are relative to the cell that contains the formula. For example:

i. Type 100 in cell A1
ii. Type the formula: =2*A1 in cell A2 so that it shows the value 200.
iii. Copy (left click, then hold down the right mouse button and select "Copy") the formula in A2 and paste it into B2 (use the right mouse button). You'll get the value "0" in B2. If you look at the formula in B2 you'll see that it is =2*B1 because to

Excel your original formula (=2*A1) in cell A2 looked like "multiply the cell above by the value two", and the cell above B2 is B1 which has nothing (value of zero) in it.

To make an **Absolute Address** you modify the formula to be copied by placing a $ symbol in front of indices that you wish to remain fixed. The modification of copying A2 could take on these forms:

Formula	Result when the formula is copied
=2*$A1	the column remains constant
=2*A$1	the row remains constant
=2*$A$1	both the row and column remain constant

Thus if you don't want references to change when you copy a formula to a different cell, use an absolute reference. A $ in a formula means a row or column index will not change when the formula is copied. As you'll see in the following exercises, absolute references are a very handy programming feature – you write a formula in one cell and can copy it to a whole range of cells (column, row or block of columns and rows).

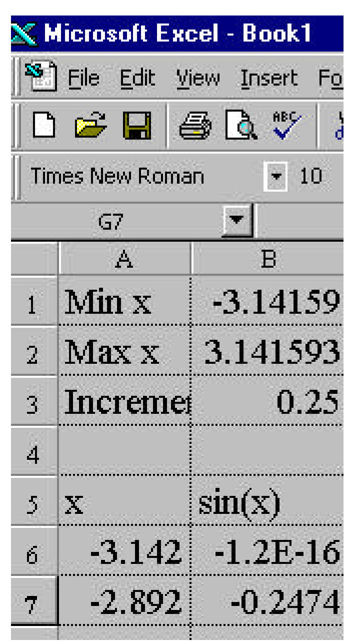
Your goal in programming equations should be to use absolute and relative addresses such that you only have to enter a formula in one cell before copying that formula to many cells.

Exercises

Lab example: Graphing Sin(x) from –pi to pi. I'll go over this on the board.

1. First put the labels Min x, Max x, and Increment x into Cells A1, A2, A3 respectively
2. In A5, B5 enter the labels x and sin(x)
3. In B1 enter =-pi(), in B2 =pi(), and in B3 enter .25
4. In A6 enter =$B$1 to make an absolute reference to the minimum value for x
5. In A7 enter =A6+$B$3 to make an absolute reference to the increment value
6. Copy A7 down a sufficient number of rows to get to 3.14159 or so
7. In B6 enter =sin(A6) and copy this formula down as for as you did for column A

The upper left of your spreadsheet should now look something like this figure. This is the general format I want you to use for all the equation graphing we do. That is, in the upper left of each spreadsheet make a table of constants, parameters and the like and refer to those with absolute and relative addresses as appropriate.



On your own:

8. Use the Graph Wizard to make a graph of sine(x) – my experience is that graphs in Excel are always a trail and error operation. And one of my objectives in this class is to get you to treat computer software on a trial and error, or experimentation, basis; so have at it. We'll all answer questions.

9. Add a column of Cos(x) to your spreadsheet and graph

10. Add a column that is a numerical estimate of the derivative of Sin(x). Hint: dy/dx is just the difference in y divided by the difference in x over the same (short) range. Probably your numerical derivative is not exactly equal to Cos(x); why is that?

Problems:

1. Construct a multiplication table for integers 1 through 15. Thus cells A1: O1 and A1:A15 should both hold the values 1→15. Now enter a formula into B2 using relative and absolute addresses such that you only have to type the appropriate formula into B2. You should be able to copy the formula in B2 to the rest of the block of cells to generate your multiplication table. **Experiment until you understand absolute versus relative addresses**.

2. In an unconfined aquifer, pumping on a well draws the water table down into a cone of depression; water flows toward the well from the side. Using the following values and variables:

   h_0 = undisturbed height of water table, 10 m
   r_w = radius of the well, 0.1 m
   p = density, 1000 kg/m^3
   u = viscosity, 10^{-3} kg/m sec
   r_0 = distance to undisturbed water table, 2 km
   k = permeability, 10^{-12} m^2
   Q is pumping rate, 25 m^3/day
   g = acceleration of gravity, 9.8 m/s^2

   graph the equation for the height of the water table at distance r from the center of the well

$$h(r) = \sqrt{h_o^{\ 2} + \frac{uQ}{kpg\,p} * \ln \frac{r}{r_0}}$$

   for r = r_w, 0.5m, and every 0.5 meters thereafter until r = 25 meters.

3. New ocean lithosphere is created at spreading centers. The initial temperature is around 1,350°C. On the order of tens of kilometers (perpendicular to the ridge axis) of new lithosphere is created every million years. As the sea floor spreads the new lithosphere cools, contracts, and increases in density. Earth, as described by the principle of isostacy, maintains nearly equal pressure at a constant depth (the depth of compensation) over large areas. The result is that ocean depth increases as the square root of the lithosphere's age:

$$d(ocean) = \frac{Pa}{Pa - Pw}\left\{2a\left(Tw - Ta\right)\sqrt{\frac{kt}{p}}\right\}$$

Pa = density of the asthenosphere; 3,300 kg/m^3

Ta = temperature of rock at ridge crest; 1,350^oC

α = coefficient of thermal expansion; 3.2*10^{-5}/^oC

k = thermal diffusivity of lithosphere; 8*10^{-7} m^2/s

Pw = density of sea water; 1,030 kg/m^3

Tw = temperature of sea water; 0^oC

a. Graph ocean depth versus age for 10^8 years.
b. On the same graph, with a different line style, graph the change in depth at each 10 million year time step.
c. Experiment with titles, legends and the like to make it look good.