Using EXCEL as an scientific and graphics calculator

Saving your work
It will be assumed that the reader has an open Excel worksheet in front of them. If you still cannot open and save an Excel ***.xls file, don’t worry about it at this stage. Once you are hooked on using a spreadsheet you will soon learn to do these things. For the start of this course we will parallel an earlier course called “Using the Sharp EL 531WH calculator”.

Basic operations
Go to any cell in the worksheet, A1 will do, and start any mathematical operation or formula with =, this tells the spreadsheet that you are going to enter a calculation. The result of the calculation will appear after you have pressed Enter on your keyboard. (This might read as Return depending on your computer keyboard.) If you make a mistake, just click, or navigate (using the keyboard arrows) back to select your cell and correct you error by typing the correct entry in the formula bar directly below the toolbars on your worksheet.

Addition and subtraction
To add two numbers, say 2 and 3 enter: =2+3 and press Enter. You will find that your cursor has dropped out of the cell, the cell now shows the answer 5. The cell you that you just used has become “active”, it is actively calculating rather than showing a number. If you reselect this cell you will find the formula bar shows =2+3 while the answer remains in that cell. You can edit or change your calculation by editing the formula bar. For instance, if you want 2+4 you can select the 3 in the formula bar and overtype 4, when you press Enter you will find your new answer. To subtract the two numbers, go back and change the “+” for a “−“ so that =2-3 now gives −1.

Multiplication and division
These operations are just as easy, provided you know that the asterisk “ ∗ ” is the multiplication sign and the fraction bar “ / ” is used for division. Thus =2*3 gives you 6 and =2/3 gives you 0.666667. You may get more or less figures depending on how many significant figures the column width and formatting allows.
If you try =-2*-3 you will see that the system applies the minuses before doing the multiplication to give 6. You will find that similar entries on a calculator will most likely give an error message. Even though the spreadsheet can sort out these ambiguities, it might still make a wrong interpretation (of syntax) and it is recommended that you use brackets whenever uncertainties may arise. A safer entry to the above would be =(-2)*(-3). With brackets, a textbook example such as 2(3+4) must be entered as =2*(3+4).

You need to be careful at first as different calculating systems use different rules, for their operations. You should always estimate your own answer and check that the answer given makes sense.

Using indices or raising a number to a power
Unlike most calculators Excel doesn’t offer an \( x^2 \) option. To get, say 5\(^2\), it is just as easy to use 5*5. The symbol used to describe \( x^2 \) is \( x^2 \), so that =5^2 will also give 25.
(You can also use a more complicated looking function =POWER(5,2); but this isn’t recommended. If you look at the Microsoft © Calculator, provided with Microsoft © Windows, you will find that this calculator, when set in the scientific mode, also uses the x^y notation.)

Excel does however offer the square-root operation. Thus the key \[ \sqrt{ \] on your calculator becomes SQRT() and you will find that =SQRT(25) will give the result 5. This expression can also be written as \( 25^{\frac{1}{2}} = 5 \) so that =25^(1/2) will also return the square root 5, as will =25^(.5).

The use of the “up arrow” operator “^” is quite general in most computing systems, so that there is no need for special cubes, cube roots etc. The \( x^{th} \) power of y, or \[ y^x \] is generally written as \( y^x \) while the \( x^{th} \) root \[ y^{\frac{1}{x}} \] is generally written as \( y^{(1/x)} \).

Scientific notation is also available in the spreadsheet. A very large number such as 6.2×10^{16} would be displayed as 6.2E+16.

**Fractions**
While the use of fractions remains essential to the understanding of mathematics, their use in computing is usually inconvenient. A textbook problem such as \[ \frac{-1}{4} - \frac{1}{5} \] can be done as =\((1/4-1/5)\) the answer will be returned in the decimal form of 0.05. If you need the answer as a fraction, then you need to change the format of the cell. Select the cell you using for your answer and ask for Format in the tool bar at the top of the spreadsheet. Select the option to format the Cells in the drop down menu and look for Fraction; when you have found this, select Up to three digits and finally OK your choice. When you have done all this, you will see that the spreadsheet result has changed 0.05 to \( \frac{1}{20} \) as required.

Be aware that for technical reasons the spreadsheet may give unreliable fractional answers.

**Percentages**
The Excel spreadsheet recognises the percentage operation in much the same way as calculators do. You need to be careful as different calculating systems use different rules, especially for percentages. You should always rely on your own understanding of percentages when calculating and check that each answer makes sense in the way that you expect.

Rather than go into explanations I will invite students to predict the results of the following spreadsheet entries and then check them using a spreadsheet.

- =60%; =60%+5%; =60+5%; =60-5%; =60%+5; =60%-3; =60*5%; =60%*5;
- =60/5%; =60%/5; =60^5%; =60%*5; =60*(1+5%); =60*(100%+5%).

**Sines cosines and tangents**
These functions can be found in the spreadsheet as SIN(), COS() and TAN(), where the required angle goes into the bracket. While finding these functions seems straightforward, there is a small problem. Because it is computer based, the Excel spreadsheet works with angles in radians. You have probably met this problem already as
calculators can also be set to DEG or RAD modes (as well as GRAD). If \( A_d \) is an angle given in degrees then the corresponding value in radians, \( A_r \) is found using:

\[
A_r = A_d \frac{\pi}{180},
\]

or in spreadsheet language

\[=AD*\text{PI()}/180.\]

Your spreadsheet may be able to convert degrees to radians; if so you will be able to find \( \sin(35^\circ) \) by using the following entry:

\[=\sin(\text{RADIANS}(35)).\]

If your spreadsheet will not recognise \text{RADIANS} as a function, you can enter instead:

\[=\sin(35/180*\text{PI()}).\]

Either method will change 35 from degrees to radians to give the correct result, 0.866025.

The inverse functions (\( \sin^{-1} \), \( \cos^{-1} \) or \( \tan^{-1} \)) are written in the form \( \text{ASIN()} \), \( \text{ACOS()} \) or \( \text{ATAN()} \). When you use these they will return answers in radians; for instance

\[\text{=ASIN(0.5)}\] returns an answer of 0.52399 rad. You will probably want to convert this back into degrees. To do this you will need to reverse the previous equation:

\[
A_d = A_r \frac{180}{\pi},
\]

or in spreadsheet language

\[=A*R*180/\text{PI()}.\]

Your spreadsheet do may do this for you using the \text{DEGREES} function, if so you enter:

\[=\text{DEGREES(ACOS(0.4))}.\]

If it doesn’t you will need to use

\[=\text{ACOS(0.4)*180/PI()}.\]

Either way, the result should be 66.42182 degrees as required.

Sometimes you may be required to work with angles expressed in minutes and seconds, as the spreadsheet prefers to use radians it will leave you to do the conversions. To convert an angle in degree, minutes and seconds; to the equivalent angle as a decimal, you take the seconds and divide these by 3600 and you take the minutes and divide these by 60, then you add these decimal values to the number of whole degrees. To enter 48°12'52" in a spreadsheet you would enter \(=48+12/60+52/60/60\). You will see that we have divided twice by 60 rather than once by 3600, both results are the same.

You may have a decimal angle that needs to changed to degrees, minutes and seconds, for example 66.42182° as quoted above. To do the conversion remove the whole number, of degrees and multiply by 60 to get the number of minutes; remove the whole number of minutes and again multiply by 60 to get the seconds. The result is 66° 25' 18.6".

**Logarithms and their inverse.**

There are two commonly used logarithm systems. The first is the natural logarithm using the base \( e=2.71828 \ldots \), this is convenient for problems in calculus. The term \( \log_e y \) is also written as \( \ln y \), the inverse to finding a \( \ln y \) value is done using the formula \( e^{(\ln y)} = y \). With a spreadsheet, we enter, say, \( \ln 2.9 \) using the entry \( =\text{LN(2.9)} \) and the result will be 1.064711. The inverse is found using \( =\exp(1.064711) \), which returns 2.90001 or some other number close to 2.9.

The second logarithm uses the base 10. The term \( \log_{10} y \) is usually written \( \log y \). The inverse (or antilog) is found in the formula \( 10^{\log y} = y \). On a spreadsheet, \( \log 2.9 \) is found using the entry \( =\text{LOG(2.9)} \) which gives the result 0.462398. The inverse is found using \( =10^{(0.462398)} \), which returns 2.9.
Mean and Deviation
These are two concepts that you will meet before you are through year 10. Despite the complexity of names and definitions in statistics, you can assume that the arithmetic mean is also the average value of a set of numbers or quantities. Hence you will find that the mean is found using the AVERAGE() function. Similar problems of occur with the definitions of deviation, we will assume that we are dealing with the standard (or sample) deviation called STDEV(). Most of the other forms are found in the spreadsheet, but if you need these you can look for them after you are familiar with using a spreadsheet.

If you have a small set of values say {3, 5, 4, 8}; you can find the average or mean of these using =AVERAGE(3,5,4,8), and you can find the standard deviation using =STDEV(3,5,4,8). These will return values of 5 for the mean and 2.160247 for the standard deviation.

If you are able to enter your values in spreadsheet cells then you can use =AVERAGE(A2:A27) where A2:A27 is the range of data found in this case in a column from A2 to A27. The same style of entry =STDEV(A2:A27) will give you the corresponding standard deviation. This last method allows you to change and correct values without having to re-enter all the data.

The spreadsheet is much more than a calculator

Using the cells
We now turn to the first, of a number, of features that makes spreadsheet more powerful and more useful than a calculator. Every cell in the worksheet (spreadsheet page) can be used as an addressable memory. You can enter a number in a cell say C12 and then later recall that cell to put that number into your calculation or formula.

At a simple level, you can put 12 in B5 and =6*B5 in the next cell say C5 and you will find the result 72 appears in C5. Although this cell appears to have a single number in it, it is really an active cell. This means that it will show you 6 times whatever number you put in B5. Try this by entering any other number in B5. The result in C5 will change but the formula for C5, shown in the formula bar, remains the same. In computing terms the active cell has become programmed. As we suggested, the spreadsheet is showing that it can act as a computer with addressable memory. You can program an equation and quickly and simply change input variables to see the output results. You don’t need to re-enter the equation every time. The spreadsheet allows you to enter comparatively large and complicated formulae and even pre-programmed “subroutines”. This enables you to change input values and effortlessly see the fresh results.

Here is an example. Suppose you are asked to plot values of the equation  \( y = mx + c \), for different values of \( x \), when \( m = 2 \) and \( c = 4 \). You could do what is suggested above and enter your value of \( x \) in B5 or any other convenient cell and then chose an empty cell and make it active by entering =2*B5+4. If B5 is empty you will get the answer 4, but now you can enter any value of \( x \) you like in B5 and straightaway see the corresponding value of \( y \) in your active cell. For instance when you put 2 in B5, you will see 8 in your active cell. It gets better. Look at the following example.
Cells A1, A2, C1 and E1 all contain characters, this means that they do not start with numbers or = signs. The spreadsheet just shows what you typed in as labels. Cells B1, B2 and D1 contain input numbers (the spreadsheet has moved these over to the right hand side of the cell). If you now go to the cell F1 (click on it) you will see the active entry up in the formula bar as =B1*B2+D1.

With this system, you can change any of the pronumerals; \( m \), \( x \) or \( c \); in the equation and the new corresponding value of \( y \) will appear in the active cell F1!

**Dropping and dragging**

You can turn your single programmed formula into a data array and thus start using the spreadsheet as a spreadsheet should be used. What we are going to do now is repeat the above exercise only this time, we will plotting values for \( y = mx + c \). We will do this so that we can look at a whole range of \((x, y)\) co-ordinates and watch their variation as we change \( m \) or \( c \) as we choose.

The worksheet that we describe is shown on the next page. At this point, we will state that the way in which a spreadsheet is laid out is a matter of convenience and taste. There is no insistence on our part that you must do exactly what we have done. We have chosen this format so that we can go on to show you some of the more advanced features of your worksheet.
We have reserved the first two rows 1 and 2 for labelling columns and placing input variables, these are $m$ and $c$ in our case. These two rows have been locked so that they will always show and remind us of the column labels (and parameter values), no matter where we go in the worksheet. Again, this process is optional, if you want to do this on your sheet, select the third row, click on **Window** and then **Freeze Panes**.

Next we have generated values of $x$ from A3 down to A24 ((A3:A24) in computer language). These values have been “dragged” to save repetition of entries. To do this for column A, you should enter the first three values -1 in A3, -0.9 in A4 and -0.8 in A5. Then select these three cells and drag them down the column; the spreadsheet will pick up the sequence and automatically put the correct number in the next cell of column A as you drag down the column. This saves you from having to enter all the values of column A individually.

Next we use a formula to generate all the corresponding $y$ values from $y = mx + c$ in column B. To do this we place our desired values of $m$ in C2 and $c$ in D2. Next we go to cell B3 and enter the formula that we need as =$C$2*A3+$D$2 and hit **Enter** or **Return** on your keyboard. Instead typing our formula in each cell of column B all the way down to B24, we can just select the cell B3 and then drag the contents down to B24. Column B has been filled with active cells. If you change the value of $m$ (in C2) or $c$ (in D2) the results from the changed formula will automatically show all the way down column B.

When you have done this, you will start to see why we gave the $x$ values an address as A3, but used the extra dollar sign $C$2 and $D$2 in the address of $m$ and $c$. When we drag the formula down the column, the spreadsheet treats A3 as a variable, so that the formula repeated in, say, B12 looks across to the cell A12 to get the $x$ value. However all the active cells interprets the addresses with $ signs as coming from the same cell $C$2 or $D$2. They have been called constants because they have a constant address.

We are now starting to see the real power of a spreadsheet; we have spread out our input data ($x$ values), we have entered a single formula and dragged this down to create the output data and we can study all our results. Better still, each time we want to change a constant in C2 or D2 we can automatically see all the new results.

**Graphing and finding the equation**
While good graphing is something of an art, it is quite easy to do quick graphs of our results, as found in columns A and B after the completing the previous section. What we can do is **Insert** a **Chart** (on the spreadsheet used for these notes there is an icon for the
Chart Wizard in the toolbar). When you have selected this “Chart Wizard” you will find that you have a large choice of Chart types, you can explore these later, but for now select XY (Scatter). You will now find you still have a range of Chart sub-type: s, we suggest that you chose the type with dots (small squares or diamonds) only; click on this picture box and then click on Next at the bottom of the box. Having done this, you will be asked for a Data Range, go to the Data range box and tell the computer that you want to graph the \( x \) against \( y \) values that start in cell A3 and end in cell B24; to do this type A3:B24 into the active box. When you go on to the Next box and you should see your graph appear, the spreadsheet will also ask you label your axes and graph (as it should) but you don’t have to, if you want a better look at your new graph, just tell the Chart Wizard to Finish. Now you should see your graph in a box on your worksheet. It should look like the following graph.

![Graph Image]

If you look at the axes you will find that the line cuts the \( y \)–axis at -1, as expected; then if you look more carefully, you will see that the line rises vertically for 2 scale units while it has a horizontal run of 1 unit. Because the computer is automatically scaling and rescaling the axes you need to read the scales carefully.

The graph you see is an active graph: every time you change the value of the constants \( m \) or \( c \), the spreadsheet automatically adjusts and replots the graph.

As you become more accustomed to using the spreadsheet you will learn to set up your graphs in a tidy fashion. For example, with more experience, you should be able to present the above graph like this:
At this stage we need to press on, we can return to these details once you are more familiar with the operation of a spreadsheet.

There is another, very handy feature that you need to meet should look at now. This goes by fancy names such as “regressive fitting”. Names aside, the spreadsheet is able to look at your data, analyse it and tell you what the equation is, or should be. This is how you can set it up. Go back to your chart and point to one of the data points in your graph, left click on this point and select Add Trendline, then select Type Linear and go to Options and select Display equation (on the chart) finally go back to your spreadsheet by clicking OK. When you look at your chart, or graph, you will see two new features. First there is a line joining all the points, the computer has calculated this line. Second, somewhere in the graph the computer will be showing you what it thinks the equation should be. This may be in the middle of the graph and look a bit untidy but you can select and drag the box over to the side as has been done below.
For this last graph, some more changes have been made. It was decided to change the value of $c$ (in D2 from -1 to +1). When this was done, the graph changed automatically, but the old label (that was printed in the box) didn’t, it still showed $y = 2x - 1$; so this was removed by left clicking and then clearing it away. The new label, with no box, is the one provided by the computer. Once your graphical presentation has been set up this way, you will see that it adjusts automatically to give the correct equation every time the constant is changed. You can also put in your own values of $x$ in column A and $y$ in column B and the spreadsheet will still tell you what the equation should be, even though neither you nor the spreadsheet knows what the equation was.

**Formatting your graphical presentation**

We have already commented to this effect “For example, with more experience, you should be able to present the above graph like” the one shown:

![Graph with axes and gridlines set up]

...to a more carefully labelled and scaled version that is ready to be cut and pasted into your larger documents.

Let us start with the lines in the graph. Go to Chart Options by left clicking with your pointer somewhere in the body of the chart, alternatively you will find this if you click on Chart in the spreadsheet toolbar. Then go to Axes and check Value (X) axis and Value (Y) axis as your options. Once you have done this you should find that your chart now has vertical and horizontal axes.

Next go back to Chart Options and select Gridlines then check for Major gridlines for both Value (X) axis and Value (Y) axis. When this has been done you should find that you have gridlines that run both vertically and horizontally.

Now we will go on to set the scale for the axes. Select one of the scale numbers on the x-axis and right click to get Format axis. Now you should set Minimum, Maximum and Major unit: we suggest that you fix these as -5, 5 and 1, leave the Minor unit at 0.2 and keep the default setting Value (Y) axis Crosses at: as 0. Next do the same for the Y-axis Format Axis. Once this is done you will find that your graph has the axes fixed to a scale running from -5 to 5 on both axes and the gridlines have a fixed spacing of 1. By now your graph should look like the following:
Now we can start adjusting the colours. Left or right click on the general chart area to select **Format Plot Area** then check **None** for **Patterns Area**. Now you will have no background colour in your chart. Go back to **Format Gridlines** for both the x- and y-axes and go to **Patterns** drop down the **Color**; box and use a light grey shade for **Lines**. Your graph should be looking like this:

![Graph with light grey gridlines](image)

Insert the trendline, by right clicking on a data point, make sure that you pick the **Option Display equation on chart**. Left click on the label box and **Clear** or delete it, then drag the equation over to replace it. You will probably decide that the points on the line are too thick. These can be reduced by Right clicking on a data point again and selecting **Format Data Series**, go to **Patterns**, select your Marker style and reduce the size to as small as possible. Finally you may need to adjust the aspect ratio of the chart, this is not controlled by the spreadsheet. Click on the graph itself, inside the chart box and drag the sides, until you are satisfied that the gridlines form visual squares. You can also adjust the chart box to your desired size and then readjust the graph inside the box, until you are happy with the size and squareness of your graph. From here you can save your worksheet so that you can always come back to the chart that you have prepared.

When you have completed these steps or learned to set the settings we have described to your own satisfaction, you should have a dynamic graph that will move about as you change the slope \( m \) in \( D\$2 \) or the intercept constant \( c \) in \( E\$3 \). Here is a sample, where we have set \( D\$3 \) or \( m = 3 \) and \( E\$3 \) or \( c = 1 \).
There are so many more options at your disposal, that you should best explore them for yourself. In effect we have shown you how to program your spreadsheet to act as a tutorial graphics package. For this package you can take over as the designer and modify it to suit your own needs and tastes.