A Simple Tutorial for Microsoft Excel

This tutorial is for students who have not previously used a spreadsheet program. There are currently a number of spreadsheet software packages available, including Microsoft Excel, Lotus 1-2-3, and Quatro Pro. Once you've used one, you will generally find it easy to use another, since these programs are similar in many ways.

Microsoft Excel is very powerful and versatile, with many advanced mathematical features; after you master the basics you will gradually learn how to use more and more of these features. This document assumes you are able to start the Excel program, either from your PC or Mac and that you know how to use a mouse. All actions can be performed either using the keyboard or by clicking the left mouse button - you will not need to use the right mouse button in this tutorial. When you launch the Excel program, you see a graphical interface that is similar to that used in other programs for Windows or Macintosh. The top row contains a number of drop-down menus: **File**, **Edit**, **Formula**, etc. You can usually do things in several different ways; for example, to open a file from a previous session, you can click **File**, then click **Open** to display the dialogue box for opening a file. Alternately, you could click on the toolbar button that has a picture of an open file folder on it.

How to get help while running Excel:

A good place to start is to learn how to access the on-line help facilities, since Excel provides extensive on-line documentation. As with many programs, pressing function key F1, or clicking **Help** provides help if you are in the midst of trying to do something and get lost, confused, or can't remember what to do next. You can also search for various topics; for example, suppose you want to delete several rows in a worksheet but have no idea how to do it - press F1, click **Search** and type *deleting* in the input box, click **Show Topics**. From the list of topics, select *Deleting cells, rows, or columns* and click **Go To**. Another way to get help is to use the toolbar button that has a question mark on it. This tool allows you to get help on whatever you select next. For example, if you haven't a clue about what one of the toolbar buttons is for, click on the question mark button and then click on the button of interest.

How to select worksheet cells and enter data:

When you launch the Excel program, you'll see an empty worksheet. A worksheet is simply a large table composed of rows and columns. Rows are identified by numbers and columns by letters. Thus cell B4 is the worksheet cell located in the 4th row and the 2nd column. A range of cells is denoted using a colon (:). For example, range A2:B10 represents a rectangular block of cells with cell A2 at the upper left hand corner and cell B10 at the lower right. In this tutorial we will use the method of least squares to solve the following problem:

Example problem

The reaction A→B is carried out in a laboratory reactor. According to a proposed reaction rate law the concentration of A should vary with time according to the equation: $C_A = C_{A0} \exp(-kt)$, where C_{A0} is the initial concentration of A (at t=0) and k is a constant. The experimental data show below are obtained for $C_A(t)$. Use the method of least squares to calculate C_{A0} and k.

time (min)	C_A (mol/liter)
0.5	1.02
1.0	0.84
1.5	0.69
2.0	0.56
3.0	0.38
5.0	0.17
10.0	0.02

We first need to enter these data into the worksheet.

1. Move the cursor to cell A1 and click - this "selects" cell A1. Once you select a cell or range of cells, the selected cell or cells are highlighted and boxed.
2. Type 0.5 to enter the first value of the variable *time*, then press **Enter** - this stores the number 0.5 into cell A1.
3. In order to input many values, the best method is to first select the range of cells where the input data will be stored. In this example, we need to enter seven values of *time* and seven corresponding values of C_A. Move the cursor into cell A1 and then press and hold the left mouse button. While pressing the button, drag the cursor down to cell B7 and then release the mouse button. Note that cells A1:B7 are now selected, with cell A1 being the "active" cell. Now you can enter the data by typing: 0.5 **Enter** 1.0 **Enter** 1.5 **Enter** 2.0 **Enter** etc. Note that after you type the last *time* value, cell B1 automatically becomes active so you can then enter the values of C_A.

<u>How to move data:</u>

You should now have the data stored in cells A1:B7 of your worksheet; however, suppose you wish to label each column so that you don't forget what these numbers refer to. To do this you need to first move the data so that you can then type "time (min)" into cell A1 and "CA (mol/liter)" into cell B1.

4. If they are not already selected, select cells A1:B7. (Again, you do this by pressing the mouse button on A1, dragging the cursor to cell B7, and then releasing the button.)
5. Notice that the cursor is normally shaped like a thick white cross when in the worksheet region. However, when you move the cursor to one of the sides of the box surrounding the selected cells, the cursor changes into an arrow (↖). When this happens, press the left mouse button and use the mouse to drag the entire range of selected cells to a new location. In this example, you only need to move one row down, so that the row 1 is now empty; however, you can in general use this procedure to drag the data to any new location.
6. After moving as described in step 5, your data should now be located in cells A2:B8. Now select cell A1 and enter *time(min)*, then select cell B2 and enter *CA (mol/liter)*. (You can't type subscripts or superscripts in Excel.)

<u>How to resize columns and rows:</u>

You may notice that the some of the labels you entered in row 1 were too big to fit into their cells. It is easy to resize columns and rows so that everything is displayed.

7. Move the cursor to the topmost row of the worksheet, the row containing the letters **A, B, C**, ...etc. on top of each column. As you move the cursor along this row (without pressing a mouse button), notice how the cursor changes from a thick white cross to a thin black cross whenever you get near the border between two columns. Place the cursor at the border between columns A and B and press the left mouse button when you observe the thin cross. You can now drag the border left or right to change the column size. When you release the mouse button, the new column size is set. Use a similar procedure to resize rows.
8. You can manually adjust column sizes as described above, or you can have Excel automatically determine the best size. To do this, again place the cursor in the topmost row at the border between columns A and B. When you observe the thin cross, double-click the left mouse button (i.e. quickly click the button two times). Excel automatically

resizes column A so that everything is displayed. Double-click at the border between columns B and C to resize column B.

How to enter a mathematical formula:

In this problem, you need to verify the exponential model: $C_A = C_{A0}$ exp(-kt). A plot of ln(C_A) vs. t should be linear on rectangular coordinate graph paper, with slope = -k and intercept = ln(C_{A0}). To perform least-squares analysis, then, *time* is the independent variable and ln(C_A) is the dependent variable. We will use column C to calculate values of ln(C_A).

9. Select cell C1 and enter the label *ln(CA)*. Then select cell C2, type =log(B2) and press **Enter**. The equals sign tells Excel that a mathematical formula is being entered. In cell C2 you should observe the value 0.0086, which base-10 logarithm of the value stored in cell B2 (1.02).

   There is a convenient shorthand method of entering formulas, in which you use the mouse to select cells: select cell C2 and type =log(Then click on cell B2 and press **Enter.**

It is important to realize that cell C2 contains a mathematical formula, and not just simply the number 0.0086. Cell C2 contains the logarithm of whatever value happens to be stored in cell B2. Try changing the value in cell B2 and observe the change that occurs automatically in cell C2. (Be sure to change the value in B2 back to 1.02 when you're done!)

How to edit a mathematical formula:

Select cell C2 and then look at the "formula bar" - this is located between the worksheet and the toolbar (just above the row containing the column buttons **A, B, C,** ... that you used in steps 7-8). The formula bar displays the mathematical formula for the currently selected cell, while the cell itself displays the numerical result of the calculation. In this case, the formula bar displays =LOG(B2) and cell C2 displays 0.0086. If you wanted to change the formula, you can click on the formula bar and then make any corrections or changes to the formula. In this problem, you need to calculate the natural logarithm, not the base-10 logarithm, so you need to correct the formula:

10. Select cell C2. Click inside the formula bar and, using the arrow and backspace keys, change the formula from =LOG(B2) to =LN(B2). Press **Enter**. You should now see the value 0.019803 in cell C2.

How to use the "fill handle":

You have calculated the natural logarithm of the first value, but now need to calculate it for the remaining six values of C_A. You could simply repeat step 10: enter =ln(B3) in cell C3, enter =ln(B4) in cell C4, etc. However, this would be rather tedious and time-consuming. A much easier method is to use the "fill handle", as described next:

11. Select cell C2. This cell already contains the desired formula and we will now repeat it for the other cells in column C.
12. At the lower right-hand corner of the box that surrounds the selected cell (cell C2) is a small square that is called the "fill handle". Place the cursor on the fill handle and you'll see the cursor change from a white cross to a black plus sign (**+**). Now press and hold the left mouse button and drag down to cell C8. When you release the mouse button, Excel automatically fills in the correct mathematical formulas in cells C3:C8. For example, click on cell C6 - in the formula bar you should see =LN(B6) displayed, while in cell C6 itself, you see the number –0.96758403, which indeed is equal to ln(0.38).

The fill handle is an extremely useful feature of Excel. Imagine a problem for which you had seventy, or perhaps seven hundred, data points instead of only seven as in the example being used here. The fill handle allows you to very quickly and easily repeat a calculation for all data points - you only have to actually type the mathematical formula one time.

How to use Excel's statistical functions:

Excel has a large number of built-in math functions, including the usual trigonometric and logarithmic functions, as well as many statistical functions that greatly simplify many calculations. Linear least squares functions are included and can be used as follows:

13. We will calculate the slope, intercept, and correlation coefficient, and store the results in cells C10:C12. In cells B10, B11, and B12 type the following labels: slope, intercept, and R2.

(Note: when using a spreadsheet, where you decide to put your data is completely up to you - you can use any region of the worksheet that is currently empty. Thus, there is nothing special about using cells A1:A8 for *time* values, or C10 for slope, or etc. In fact, you could have chosen to store the experimental values of *time* and C_A in row format rather than column format. The arrangement of the worksheet is entirely up to you. Also, using text labels to identify the contents of certain columns, rows, and cells is not required, but highly recommended so that someone else looking at your worksheet can understand it.)

14. Select cell C10 - you will now calculate and store the slope in this cell. To look at a complete list of Excel functions, click **Formula**, then click **Paste Function**. This action opens a dialogue box that lists all of the built-in mathematical functions. You can use the scroll bar in the **Paste Function** box to view the list. In the box labeled **Function Category**, click *Statistical*. In the box labeled **Paste Function**, scroll down and click *Slope*. Below the **Function Category** box you should now see the following:

    SLOPE(known_y's,known_x's)

    This tells you how to use this function: SLOPE() requires two arguments - a range of y-values and a range of x-values. You can click the **Help** button in the dialogue box to get additional help and information on the currently selected function. Clear the **Paste Arguments** check box by clicking on it. Then click **OK**. You should now see =SLOPE() in cell C10 and in the formula bar, with the cursor located between the parentheses.
15. Select cells C2:C8 with the mouse (this is the range of cells containing the known y-values), then type a comma (,), then select cells A2:A8 (this is the range of cells containing the known x-values). Press **Enter**. In the formula bar you should see =SLOPE(C2:C8,A2:A8) and in cell C10 the number -0.41372.
16. If you already know how to use a function, you do not need to use **Paste Function**. In fact, you already did this when you used the LOG() and LN() functions in steps 9 and 10. The other two function we need here are INTERCEPT(known_y's,known_x's) and RSQ(known_y's,known_x's). Select cell C11 and type =intercept(Then select cells C2:C8, type a comma, then select cells A2:A8, then press **Enter**. Repeat in cell C12 using the RSQ() function to calculated the correlation coefficient, R^2.
17. Now you can calculate the two parameters (rate constant (k) and initial concentration (C_{A0})). Enter the following labels and formulas in the indicated cells of your worksheet:

B14	k (1/min)
C14	=–C10
B15	CA0 (mol/liter)
C15	=exp(C11)

    If you made no mistakes, you should see that k = 0.413 min^{-1} and C_{A0} = 1.29 mol/liter.

How to use absolute references to cells in a worksheet:
Now let's use column D to calculate values of C_A using the model equation $C_A = C_{A0} \exp(-kt)$ so that we can compare the calculated values with the actual experimental values in column B.

18. Select cell D1 and enter the label *CA_calculated (mol/liter)*.
19. Select cell D2 and enter the formula =C15*exp(-C14*A2) (This is correct because C_{A0} is stored in cell C15, k is stored in cell C14, and variable *time* is stored in column A.) Remember that you can either type cell references (C15, C14, etc.) into a formula, or use the mouse to make the selections (this is easier). You should see the number 1.045371 in cell D2.
20. Rather that repeat step 19 for cells D3:D8, you can use the fill handle as described in steps 11-12. Select cell D2 and drag the fill handle down to cell D8.

You should then see zeros in cells D3:D8. Obviously, this cannot be correct - what went wrong?? To answer this, select cell D3 and look at the formula bar - you should see the following formula: =C16*EXP(-C15*A3). This is wrong - what you wanted in this cell is =C15*EXP(-C14*A3). Now you see the problem - when you used the fill handle, Excel automatically incremented all cell references. You want it to increment values from column A, but you need to use the values in C14 and C15 in all calculations. You can correct this by using **absolute cell referencing**, as shown below:

21. Select cell D2. In the formula bar, use the mouse to place the cursor immediately in front of the reference to cell C15 (i.e. place the cursor between the equal sign and the letter C). Then press the F4 function key on the keyboard. In the formula bar, you'll see that the reference C15 has been changed to C15 - the dollar signs ($) tell Excel that this is an absolute reference and not to be incremented. Next, place the cursor immediately in front of the reference to cell C14 and press F4. Then press **Enter**. The formula bar should now show the following for cell D2: =C15*EXP(-C14*A2).
22. With cell D2 selected, grab the fill handle and drag down to cell D8. Now you should see the correct values.

Your worksheet should now look like the table shown below:

	A	B	C	D
1	time (min)	CA (mol/liter)	ln(CA)	CA_calculated (mol/liter)
2	0.5	1.02	0.019802627	1.045371228
3	1	0.84	-0.174353387	0.85002501
4	1.5	0.69	-0.371063681	0.691182709
5	2	0.56	-0.579818495	0.562022919
6	3	0.38	-0.967584026	0.371600551
7	5	0.17	-1.771956842	0.162450478
8	10	0.02	-3.912023005	0.020527337
9				
10		slope	-0.413723142	
11		intercept	0.251233635	
12		R2	0.999645603	
13				
14		k (1/min)	0.413723142	
15		CA0 (mol/liter)	1.285610413	

How to create a chart or graph:
Finally, you will create a graph to compare the experimental and calculated values of C_A. The first step is to select all the cells containing the data you wish to plot.

23. Select cells A1:B8. Note that this range includes cells A1 and B1, which contain the labels.
24. Press and hold the control key (**Ctrl**) and then select cells D1:D8. The control key is used to select non-contiguous (i.e. unconnected) regions on a worksheet. This is necessary here because you do not wish to plot the values in column C.
25. Click the **Chart Wizard** tool button on the Excel toolbar - this is the button with a picture of a bar chart and a magic wand.
26. Click and drag inside the worksheet to create a rectangular box for the graph. The size and location are not important, since you can move/resize the graph later.
27. The **Chart Wizard** dialogue boxes lead you through the steps need to construct a graph. You will be asked to enter the input range and the type of graph you wish to construct (bar chart, column chart, line, x-y scatter, etc.) Since you have already selected the input range, as described in steps 23-24, the correct input range should be already displayed. Click **Next**, then select **XY (Scatter)** for chart type. Click **Next**, then select format 2 for graph format. Click **Next** and specify the following options: Data Series in: <u>Columns</u>; Use first column for: <u>X Data</u>; Use first row for: <u>Legend Text</u>. Click **Next**, then type a title for your graph and labels for the x and y axes. Then click **OK**. You should now see your graph "embedded" in the worksheet.

<u>How to edit a chart or graph:</u>

Once you've created a chart, you can edit it at a later time by simply double clicking inside the chart region. You can then edit various features of the chart. For example, in this case, suppose you decide not to connect the points for the experimental data:

28. Double click anywhere inside the chart region. Then double click one of the red squares, which correspond to experimental points, column B. This opens the **Patterns** dialogue box. Under **Line**, select **None** and click **OK**. (Since the experimental and calculated points nearly overlap on this particular chart, if you have trouble successfully selecting the red curve, you could do step 29 first, and then come back to step 28.)
29. Now double click one of the green squares, which correspond to calculated values, column D. In the **Patterns** box, under **Marker**, select **None** and click **OK**.
30. When you've finished editing the chart, click **File** from the top menu bar and click **Close**.

<u>Advantages of a "live" spreadsheet:</u>

One of the most powerful features of a spreadsheet program is that it is a "live" document. For this reason, it is very easy to correct errors in data input or to look at different scenarios. It is also easy to experiment with how changing one or more of the input values affect the final results. For example, suppose you find that you made a mistake when entering values of C_A way back in step 3 - let's say that the value of C_A at 0.5 min should have been 2.00 mol/liter instead of 1.02. Select cell B2 and enter the number 2.00 - as soon as you press **Enter**, notice how all calculations (including the slope, intercept, and data plotted in the graph) are immediately updated to take into account the new value.

Be sure to change the value in cell B2 back to 1.02. Then click **File**, then **Save As...** to store your worksheet (graph included) to a file on a floppy disk.