

## Chapter 4. Spreadsheets

We've discussed rather briefly the use of computer algebra in §3.5.

The approach of relying on `www.wolframalpha.com` is a poor substitute for a full-featured computer algebra program running on your own computer, one reason being the inability to store intermediate results in `www.wolframalpha.com`. This means the power arising from multi-step calculations, and the possibility of writing your own reusable programs inside the system is lacking.

We will now discuss the idea of a spreadsheet and some simple applications.

### 4.1 A little on Spreadsheets

Spreadsheets are computer versions of an accounts ledger. They are used frequently in business, but have wider uses. In particular they are often used to manipulate experimental data (in some fields other tools are more often used) and you may encounter them in your labs. The idea then is to give you a rudimentary knowledge of spreadsheets so that you may know where to start if you need to use one in the lab.

First where do you find a spreadsheet programme to use? People usually assume that you have one on your computer, called Microsoft Excel, and maybe even use the word “Excel” rather than “spreadsheet”. However, if you have a computer at home it would possibly have cost you extra to get Excel (and PowerPoint) for it. I think you need Microsoft Office Professional to get them, at least if you got your computer after some date like the year 2000. At one stage Windows computers tended to have all this software on them whether you really wanted them or not, but that is no longer automatic. And Macintosh or Linux computers possibly won't have Excel (again unless someone takes care to get it). The PCs and Macs in the College computer labs do have Excel.

There are alternatives to Excel that do more or less the same job, at least up to some level of sophistication. I think LibreOffice or OpenOffice are good options. You can download one or the other for free from `www.libreoffice.org` or `www.openoffice.org` and that will give you a replacement for Microsoft Office (Word, Excel and Powerpoint at least; it can read and write [most] files from Microsoft programmes). For a Mac you might find Neoffice `www.neoffice.org` best. I suppose downloading these is easy if you have a good network connection, but they are quite big.

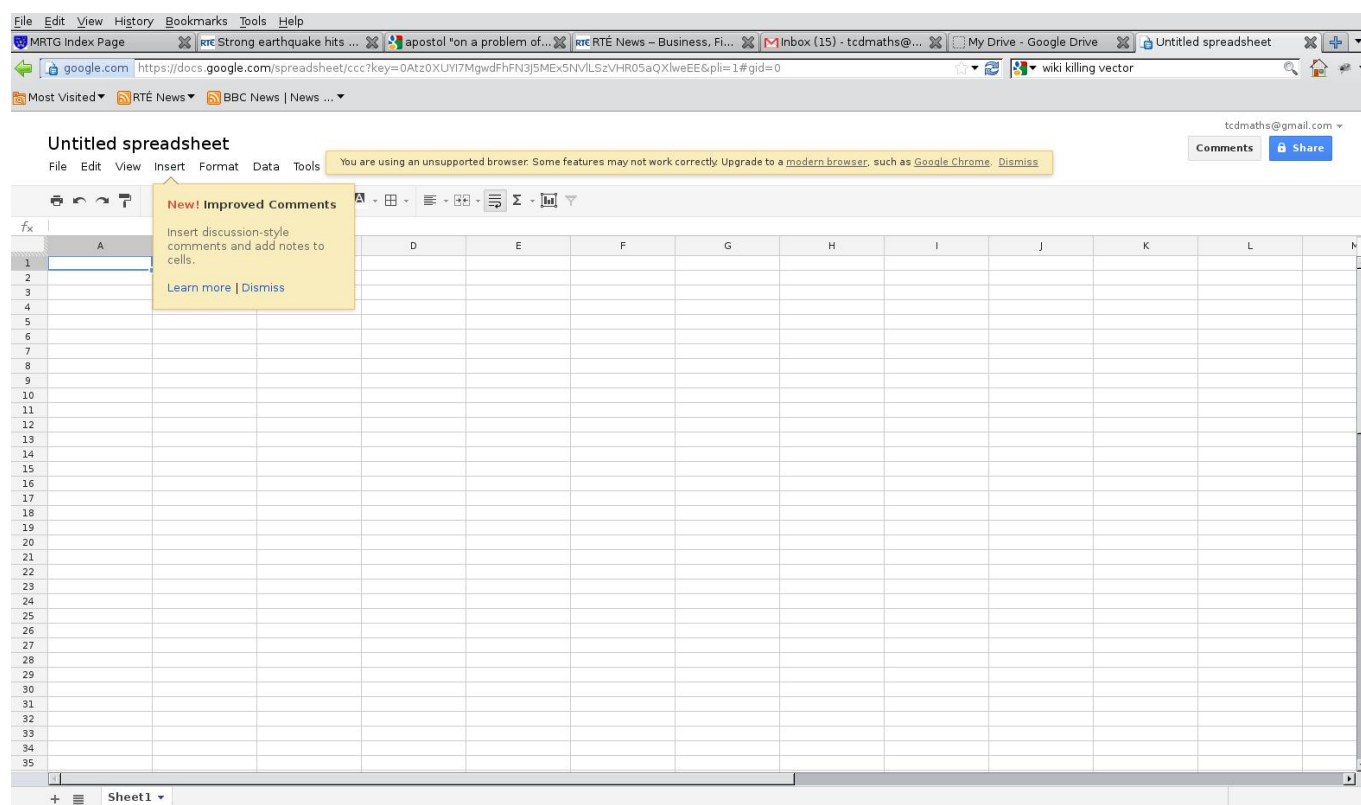
There are other options too, including several other spreadsheet programs that you don't have to pay for.

The option we will discuss is using a Google spreadsheet online, which is offered as part of the *Google Drive* the facility of gmail e-mail service. (As your TCD email account is on gmail, you have access to Google spreadsheets. Click on the **Drive** item at the top of the screen when logged in, then **CREATE** a new Spreadsheet to get started.)

As far as I can see the facilities provided by Google spreadsheets are convenient to use and adequate at least for discovering the basic ideas. Maybe not all statistical tools are as readily available as on Excel (for example).

## 4.2 What a spreadsheet looks like

When you start a spreadsheet programme (with nothing saved from before) you should see a grid like the one in the next picture. There are various menu items across the top, various magic shortcut icons around the top and/or side, and the essence of the thing is the grid. The rows of the grid are numbered 1, 2, 3, and so on, while the columns are labels A, B, C, etc. You would normally see a bigger number of rows and columns than what is shown here.



The little tabs at the bottom called sheets allow you to have several pages, like in a ledger book, with separate or related stuff on the other sheets. But we will just try to explain what you can do sticking with one sheet.

In the picture the top left box, the one in Column A and Row 1, is highlighted (or selected), as indicated by the blackened square around that box, and also you can see A1 written somewhere above. What you can do is put stuff in the different boxes. We call these boxes *cells* of the spreadsheet and the (main) things you can put in these cells are

- (i) a number
- (ii) a word or some words, or any text
- (iii) a formula

In this way it is like a ledger book you might have seen someone use for accounts, except that the formula option is different. You might think the boxes are too small to enter much text but you can resize the columns (make them wider or narrower) by dragging with your mouse on the boundary between columns across the top (where the A, B, C, etc. are). You can also make a row deeper, or get the thing to ‘wrap’ lines in a cell and then resize rows automatically to fit the deepest cell in that row.

You do these things with the Format → Cells menu item in several programmes (but Google Drive has a rather different Format → Number selection). To get the line to wrap under itself at word breaks, you pick the ‘Alignment’ tab in that menu and check the box for ‘Automatic line break’. (Google Drive wraps anyhow.)

But to get some words in (or a number) just type the number with some particular cell selected. Type `Return` or press `Tab` when you are done.

You can move round to different cells by clicking on them with the mouse, or with arrow keys.

The real power of a spreadsheet comes from the ability to enter formulae into cells, and the possibility that the formulae can read values out of other cells. The first rule is that a cell beginning with an equals sign is interpreted as a formula. (If you happen to try entering text that begins with an equals sign, such as `=Total` you will get a peculiar outcome, indicating an error.) If you type in, say `=5+6` (and press return), `11` will show in the cell. When you click on the cell, the actual formula will still be there, but it looks just like you typed in the `11` for the rest of the time.

You can put arithmetic formulae using `+` for addition, `-` for subtraction, `*` for multiplication, `/` for division and `^` for “to the power of”. You use round brackets for grouping. So `=(5+6/9)*8` will come out to `45.33333333`. You can also use lots of standard functions, too many to list here. The notation is like `=sin(1.2)` although the function names are case-insensitive (so that `=SIN(1.2)` and `=Sin(1.2)` will do the same).

The real advantage of a spreadsheet is that formulae and functions can refer to values entered in (or computed) in other cells. So say in cell *B5* (meaning the one in column B, row 5) we have entered in `1.2` and then in cell *D5* we enter in `=sin(B5)`. Cell *D5* will then show the value of `sin 1.2` (which is `0.932039`). But if you later change the entry in *B5*, the value in cell *D5* will automatically change accordingly.

Another helpful thing is how copy and paste works. If you want to replicate what is in cell *B5* all the way down column B, from cell *B6* to *B15*, this is what you can do. Highlight (or click on) cell *B5*. Using the Edit menu, copy that cell (or just use the keyboard shortcut `Control-C`). Then drag your mouse from cell *B6* down to cell *B15*. When you let up the mouse button those cells will still be highlighted. Press Paste (in the Edit menu, or the keyboard shortcut `Control-V`) and what is in cell *B5* will be copied into each of the positions *B6* down to *B15*.

Now if, as seems to be the case above, cell *B5* just contains a fixed value `1.2`, this is a minor convenience. Easier than retyping the number `1.2` ten times. (If you did it in cells *B6* down to cell *B105* it would save you typing `1.2` a hundred times.) But, now comes the value of what is called ‘relative references’. Suppose we copy cell *D5* (where we had entered `=sin(B5)`) in the same way, and paste it into cells *D6* down to cell *D15*. What goes into the cells is then changed so that the reference is changed in each one. In cell *D6*, it will become the formula `=sin(B6)`,

on the grounds that  $B6$  is in the same position (2 cells left) *relative to* cell  $D6$  as cell  $B5$  is to cell  $D6$ .

### 4.2.1 Example

Suppose we want to calculate the values of  $y = \cos(x)$  for  $x = 0, \pi/10, 2\pi/10, \dots, 20\pi/10 = 2\pi$ . (Maybe we want these values for a graph.)

In fact for this kind of mathematical graph, spreadsheets are probably not what you should use. But we'll use it now for this anyhow.

Let's enter this in the cells

	A	B
1	0	=cos (A1)
2	=A1 + pi () /10	
3		
4		
5		
6		
7		
8		
9		
10		

(Here the `pi ()` is a way to get at the value  $\pi = 3.1415\dots$ ) This is what you will see

	A	B
1	0	1
2	0.31	
3		
4		
5		
6		
7		
8		
9		
10		

Now copy cell  $A2$  and paste it into all the positions  $A3$  to  $A21$ . And copy cell  $B1$  and paste that into all the positions  $B2$  to  $B21$ . Just to clarify, the effect will be the same as if you had typed all the formulae in the left side of the following, but what you see will be like the right.

	A	B		A	B
1	0	=cos(A1)	1	0	1
2	=A1 + pi()/10	=cos(A2)	2	0.31	0.95
3	=A2 + pi()/10	=cos(A3)	3	0.63	0.81
4	=A3 + pi()/10	=cos(A4)	4	0.94	0.59
5	=A4 + pi()/10	=cos(A5)	5	1.26	0.31
6	=A5 + pi()/10	=cos(A6)	6	1.57	0
7	=A6 + pi()/10	=cos(A7)	7	1.88	-0.31
8	=A7 + pi()/10	=cos(A8)	8	2.2	-0.59
9	=A8 + pi()/10	=cos(A9)	9	2.51	-0.81
10	=A9 + pi()/10	=cos(A10)	10	2.83	-0.95
⋮			⋮		
21	=A20 + pi()/10	=cos(A21)	21	6.28	1

### 4.2.2 Graphs

Graphs (or charts) seem to me to work differently in different programs. With the Google version and the above data, you could highlight cells *A1* to *B21* and click on the icon for a graph (or find it in the **Insert** menu). You'll then be presented with various types of graphs or charts to choose from and the option to use column *A* as labels for one axis.

The Google spreadsheet will display  $\pi$  to more than two places by default. If you want only two displayed, use format on the cell (or click the '123' icon at the top with the cells highlighted).

## 4.3 Absolute references

We may sometimes want to refer to a fixed value, like a tax rate or a VAT rate in a spreadsheet. Or maybe the concentration for some acid, or a PH value. But we might want to allow for that value being changed, and then we want to be able to change our calculations accordingly.

We could find a place where we are going to put that value, say cell *D2*. We could enter 1.23 into that cell for the multiplying factor to add VAT. Now in column *A* we might list a description of various items we spent money on, in the next column *B* the cost before VAT of those things, and in column *C* we might want the cost including VAT. We could enter in cell *C1* the formula =B1\*1.23 and copy that down column *C*. That would work, but if we have to change the VAT rate we would have to alter all the formulae. If we put =B1\*D2 in cell *C1*, and copy that to cell *C2*, it will become =B2\*D3, but that is not what we want. We want to get the value in *B2* times the value in *D2*.

This can be done by inserting in cell *C1* the formula =B1\*\$D\$2. The \$D\$2 reference stays as \$D\$2 even after it is copied and pasted. So now if we paste that into cell *C2*, it will become =B2\*\$D\$2, and still refer to the constant 1.23 we have entered in cell *D2*.

Let's say we create this spreadsheet,

	A	B	C	D
1	Item	Cost ex VAT	Cost inc VAT	VAT Rate
2	Door	97.32	=B2*\$D\$2	1.23
3	Lock	23.55	=B3*\$D\$2	
4	Brass handle	18.35	=B4*\$D\$2	
5	Hinges	15.19	=B5*\$D\$2	
6			=B6*\$D\$2	
7			=B7*\$D\$2	
8			=B8*\$D\$2	
9			=B9*\$D\$2	
10	TOTAL	=sum(B2:B9)	=sum(C2:C9)	

where we are showing what was typed into each cell. However, cells *C3* to *C9* could be arrived at by copying and pasting from cell *C2*. It would not save you much, but cell *C10* could also be got by copying and pasting from cell *C9*.

The result you would see on the screen would look something like this:

	A	B	C	D
1	Item	Cost ex VAT	Cost inc VAT	VAT Rate
2	Door	97.32	117.76	1.23
3	Lock	23.55	28.5	
4	Brass handle	18.35	22.2	
5	Hinges	15.19	18.38	
6			0	
7			0	
8			0	
9			0	
10	TOTAL	154.41	186.84	

You might fill in further items and their costs into columns *A* and *B* (rows 6 to 9 are still free). As you do that the totals will be updated. Changing the VAT rate entry 1.23 would change the numbers in column *C*.

You might also want to adjust the formatting on the cells *B2* to *C10* to show 2 decimal places and a perhaps a currency symbol. There are too many tricks you can do to even pretend to tell you about them.

#### 4.4 Further features

As mentioned already, spreadsheets can do such a range of things that we can't really hope to convey many of the finer points.

About functions that spreadsheets know about. There are really lots, too many to try and explain. Anyhow we don't have the background to understand them all (especially those related to statistics). Here is a small selection

**cos(), sin(), exp(), ...** Lots of mathematical functions.  $\exp(x)$  means  $e^x$ .  $\cos(x)$  is the  $\cos x$  we use in calculus (with  $x$  in radians).

**sum()** Adds up the numerical values in the range. Could be `=sum(A1:B10, C3)`

**average()** Divides the sum of the numerical values in the range by the number of them.

**count()** Counts how many numerical values there are in the range.

So `=sum(A1:B10)/count(A1:B10)` should be the same as `=average(A1:B10)`

**counta()** Counts how many not blank entries there are in the range. So a cell with text in it will count.

**max(), min()** Picks the largest (smallest for min) value among those you feed it.

**if()** This allow for complicated things.

A simple example is the formula `=IF (A2>39, "Pass", "Fail")`

It means if the value if A2 is more than 39, then put the word Pass. If not, put the word Fail. Instead of words, you could have formulae. You could programme a rule that charges 20% tax up to 1500 euro and 40% on anything above like this

`=IF (A2>1500, 0.2*1500 +0.4*(A2-1500), 0.2*A2)`

#### 4.4.1 Matrix operations

Matrix-valued functions seem mysterious to work in some spreadsheet programs but in Google they seem quite easy.

For instance the `MINVERSE()` and `MMULT()` functions work quite well. You need to feed the `MINVERSE()` a range of rows and columns that make a square matrix. It produces error codes if the matrix has no inverse. For `MMULT()` you need to feed it two blocks so that the sizes of the blocks make up matrices that can be multiplied. For instance the formula `=mmult(A2:C3, A2:A4)` will multiply the  $3 \times 2$  matrix given by the entries in the block A2 to C3 times the  $3 \times 1$  block (column) given by the numbers in A2 to A4.

The `SUMPRODUCT()` function can do dot products and there is a `TRANSPOSE()` to do matrix transposes. Later you may find it useful to know about `MDETERM()` (which finds determinants).

## 4.5 Help

There are help menus in all spreadsheets I've seen recently and there are also menus you can put up showing all the available functions (of which there are a few hundred predefined).