# MAS115 PRESENTATION LAB, WEEK 10

## 1. Investigating mathematics with spreadsheets

This week we will look using spreadsheets to investigate mathematical problems, including tips for presenting the findings well.

**Excel.** You probably know Microsoft's *Excel* software, which is widely used. There are other spreadsheet programs we could use. I strongly recommend *Open Office*, which is free and has all the same functionality. However, Excel is already installed on the University's PCs and is the most likely package you will encounter in a workplace, so we'll use it for now.

Start Excel by finding it in the start menu.

> *The basics: a spreadsheet consists of* cells*, each of which is has an address, such as A2 (first-column, second row). Inside each cell can either go a value — text or a number — or a formula. Formulas must start with an '='-sign.*

**Projectiles.** Go to the course website and save the file called `projectiles.xlsx` found in the Week 11 lab materials. Open this in Excel.

By looking at the contents of the cells, try to work out what it does. The presentation is poor, so this won't be easy. We will improve that.

(1) Insert a row at the top of the spreadsheet. The best way to do this is to highlight row 1, right-click and choose `insert`.
(2) Label the three columns of data. (Hint: one represents time, and the other two represent coordinates of a projectile in flight.)
(3) Make your column labels bold and right-aligned.
(4) Highlight the time data, right-click and select `format cells`. Select the `Number` format, choose 1 decimal place and click OK.
(5) Format the $x$ and $y$ columns to have 2 decimal places.

> *You've probably noticed that some cell references have $-signs in, e.g.* $A$1*. These are what's known as* absolute references*. Absolute references don't change when using the* fill handle *(see later).*

Hopefully the data is looking better now. You will notice that, on the right, there are parameters that are referenced in the formulas calculating the $x$ and $y$ values.

(6) Insert a column by highlighting column $E$ and choosing insert after a right-click.

(7) Label the four parameters in the column you created. (Hint: one is the angle of launch, $\theta$ say[1], one is the initial $y$-value, $y_0$ say, one is the initial speed, $v_0$ say, and one is the gravitational constant $g$.)
(8) Center the labels you just created. Format the values to be displayed to 2 decimal places.
(9) Create titles of 'Parameter' and 'Value' for the two columns in your table.
(10) Add a column called 'Description' between your two columns, and give a short description of each parameter (e.g. 'Initial speed').
(11) I've decided that the 'Description' column works better after the 'Value' column, so highlight the column, then cut and paste it.

Let's draw a graph of the flight of the projectile. Highlight the data in the table corresponding to the $x$ and $y$ coordinates, including the titles, then go to `Insert`, `Scatter`, `Scatter with Smooth Lines` from the menu at the top. Drag this graph to a suitable place on the page. Try changing the parameters (other than $g$!) to vary the projectile's path.

To make sure the projectile can't disappear below ground level, insert a new column to your main table called '$y$ (with floor)'. In the top cell, use the `IF` function in Excel to make that cell display the $y$ value if it is positive and 0 otherwise. Excel should help you as you start to type '`=IF(...`'. Use the *fill handle* to complete the rest of the column.

> *Search youtube for 'How to Use the Fill Handle' and watch the 1 minute video made by* `excel-formulas.com` *if you don't know how.*

Delete the graph, then re-plot the $x$ values against the adjusted $y$ values. Alternatively, edit the data range for the graph if you can find out how.

Finally, the spreadsheet needs a title. Insert two blank rows at the top, and in cell $A1$ type 'Projectile motion'. Make the title 18pt and bold.

**Euclid's algorithm.** You have covered *Euclid's algorithm* for finding the highest common factor of a pair of integers in MAS114 and in the Python section of MAS115. Let's look at implementing it in Excel.

Start a new spreadsheet and save it. As a test run, we'll use the numbers 1001 and 132.

(1) Enter '`a`' in cell $A1$ and '`1001`' in cell $B1$.
(2) Enter '`b`' in cell $A2$ and '`132`' in cell $B2$.
(3) In $D1$ enter '`Remainders`'. In $D2$, put '`=B1`'. In $D3$ put '`=B2`'.
(This column will keep track of the successive remainders that appear in Euclid's algorithm.)
(4) To keep track of the quotients, give column $E$ the title 'Quotients'. Leaving $E2$ blank, make $E3$ calculate the integer part of $D2/D3$.
(The function `INT` will be useful here.)
(5) Use the quotient you just calculated to enter the next remainder in cell $D4$.

[1]You can insert greek symbols into Excel; look under the `Insert` menu at the top

(6) Continue in this way to calculate further quotients and remainders. You should use the fill handle to make this automatic.
(7) Eventually, you'll find a remainder of 0 appearing. What's the conclusion at this stage? Why do you see errors appearing subsequently?

Essentially, the algorithm is now complete. Change the numbers $a$ and $b$ to see the workings change. As usual, a bit of effort with the presentation here can make the spreadsheet much more usable.

Start a column to the right of the 'Quotients' column called 'Description'. We'll use the `CONCATENATE` function to give a description of what the calculation has shown at each stage.

(8) In cell $F3$, use `CONCATENATE` to display the statement '`D2=E3*D3+D4`'; that is, giving the output '$1001 = 7 * 132 + 77$'.
(Hint: `CONCATENATE` joins together strings, like the `+` operator in Python. Here, you need to join the value in $D2$, an '='-sign, the value in $D3$, a '$*$'-sign, etc.)
(9) Use the fill handle to complete the rest of the column.

Now to get rid of the unsightly error messages. The function `IFERROR` is good for this, which gives an alternative output for a formula if the formula returns an error.

(10) Wrap your formula in $D4$ in an `IFERROR` command to give a blank string instead of an error message. That is, change '`=formula`' to '`=IFERROR(formula,"")`'.
(11) Use the fill handle to drag this down. You should see the error messages disappear.
(12) Use the same techniques on the other columns containing error messages.

*Make sure everything is working at this stage by altering a and b and watching the content of your spreadsheet change.*

A nice touch would be to display the sentence 'The highest common factor of $*$ and $*$ is $*$' at the top of the page. Try to find a valid approach. Have a look at my lab attempt on the course webpage if you get stuck.

All that's left to do is to add two rows at the top, and put in the title 'Euclid's algorithm' in 18pt bold.

1.1. **Using solver.** As a final task, let's look at the *Solver* feature of Excel, which can maximise or minimise expressions subject to constraints.

On the course webpage, download and save the spreadsheet called `solver.xlsx`. The spreadsheet shows data for unknown function $f$. Our task is to try to to fit an appropriate curve.

Notice that the plot of the data shows something that looks like a *damped oscillation* (that is, a sine curve that becomes increasingly less energetic). An appropriate function to try to fit here would be something of the form $g(x) = e^{-Kx}(A + B\sin(Cx + D))$, since data is off-axis damps towards zero. Let's see if this hunch is correct.

(1) In column $C$, put the title $g(x)$. Enter a formula in $C6$ which calculates the function $g$ as given above, using the `EXP` function and the parameters $A$–$K$ that appear in the given table.
(2) Use the fill handle to complete the column. Do you notice a problem? Look carefully at the formula in the filled cells.
(3) Unless you were already wise to the situation, you will have found that the references to the parameters changed as you filled the column. To correct this, you will need to use *absolute references* for the parameters in your original formula (e.g. \$$G$\$6). Amend the formula, and fill using the fill handle.

    *A quick way to change to an absolute reference when typing a formula is to press* `F4`.

(4) In column $D$, work out $(f(x) - g(x))^2$. This will give a positive number which measures the difference between the curves.
(5) Use the `SUM` function to give the total for column $D$, placing it at the bottom of the column.

Here's the clever bit! We're going to get Excel to work out the best possible values for the parameters by minimising the sum of the squared differences you just calculated. To do that, we use Solver.

To enable Solver, go to `File`, then `Options` and select `Add-ins`. At the bottom, find the bit that says `Manage: Excel Add-ins` and click `Go`. Select `Solver` and click `OK`.

Now, look in the `Data` menu at the top. You should see Solver on the right-hand side. Click to start it.

We want to minimize the cell containing the sum of the squares by changing the parameter values. Thus,

(6) set the target cell to the one containing the sum of the squares;
(7) select `Min`;
(8) select the cells containing the parameter values in the 'By Changing Cells' box;
(9) click `Solve`.

All being well, Solver will work out the best possible parameter values. Check the graph to see if it's been successful.

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## Homework

There is no homework this week, as this is the final presentation lab for Semester 1. Also, your first group project will be released on Thursday, which will probably keep you busy.