PDHonline Course G196 (4 PDH)

Excel Spreadsheet Basics for Engineers

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Excel Spreadsheet Basics for Engineers

Robert B. Wilcox, P.E.

Disclaimer

The example spreadsheets provided in this course are provided for illustrative teaching purposes only, and are not intended for use in any specific project. Anyone making use of the information contained in these spreadsheets does so at his/her own risk and assumes any and all resulting liability arising from their use.

Course Content

Prerequisites and Required Software

Before proceeding, the student should have a basic working knowledge of a personal computer, and have available a working copy of Microsoft Excel or similar compatible program. No prior knowledge of Excel is assumed.

Example Spreadsheet Links

For most of the examples, you can build the spreadsheet up easily yourself. But if you want a head start, you can load up most of the examples by following one of the links below with "CTRL + click".

spreadsheet_examples\data_table.xls
spreadsheet_examples\data_table2.xls
spreadsheet_examples\financial.xls
spreadsheet_examples\friction.xls
spreadsheet_examples\metals.xls
spreadsheet_examples\simple_beam.xls
spreadsheet_examples\stats.xls
spreadsheet_examples\statsstart.xls
spreadsheet_examples\trajectory.xls

The Basic Elements of a Spreadsheet

A spreadsheet is essentially a matrix, referenced by rows and columns. Each of the boxes is defined by a letter and a number, the letter indicating the column, and the number indicating a row. A worksheet is the same as a spreadsheet, and a workbook can have many worksheets or spreadsheets contained within it. Go ahead and open a new file in Excel, or similar compatible program. When you first open a new spreadsheet in Excel, it looks like this:
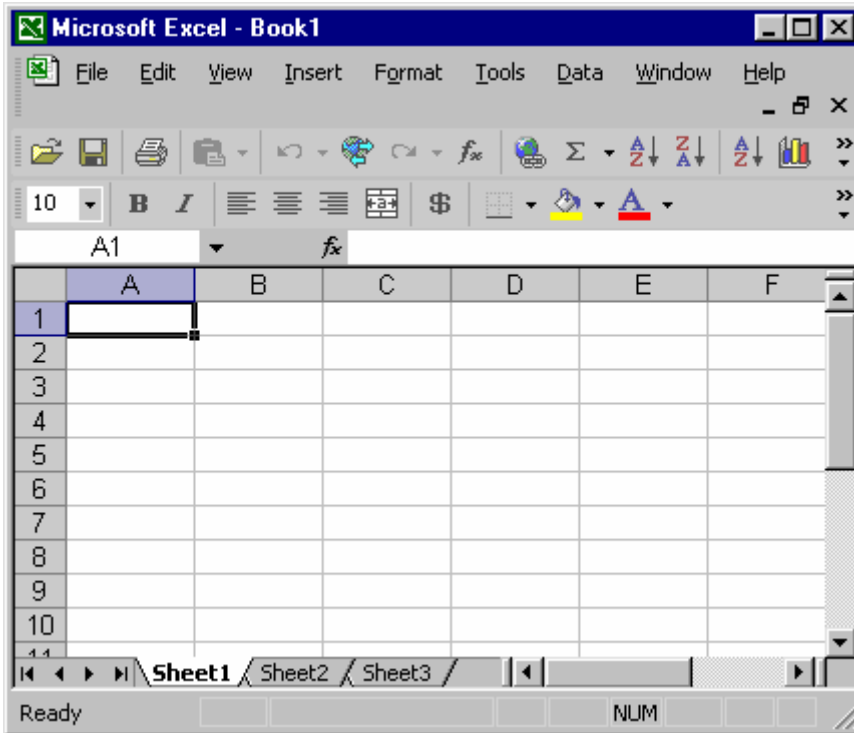
The basic elements then are:

- *Worksheet:* These are each a matrix, and right now you can see "Sheet1", "Sheet2" and "Sheet3" are the default sheets in a new workbook.
- *Workbook:* A group of spreadsheets, stored in a single file is a workbook.
- *Row:* The numbers on the left are the row labels.
- *Column:* The letters across the top are the column labels.
- *Cell:* A single location in the matrix, is a field where data and formulas can be stored.
- *Cell Address:* The address of a cell within a worksheet is the letter and number of the cell. Right now the cell "A1" is selected in the figure above.

Entering Data

To enter simple data like numbers or text, simply click on a cell, and type the data. When you are working in a cell, the field of the cell is shown in an editing box at the top of the spreadsheet. You may edit directly in the cell, or in the editing box. To use the editing box, click first on the cell you want to edit, then on the editing box. When you are finished editing in the edit box, click the green check to the left to keep the changes, and click the red "x" to discard the changes. When editing directly in the cell, simply hit "enter" on your keyboard to keep the changes, and move to then next cell down in the spreadsheet. First, lets make column "A" wider - move your cursor to the line between the "A" label and the "B" label, and click and drag it to the right to resize the column until it looks something like this:
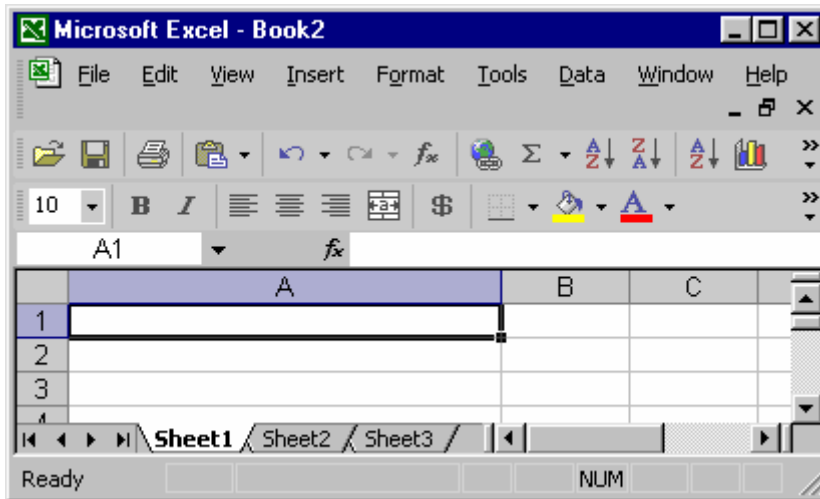
Go ahead and enter data in your spreadsheet until it looks like this:
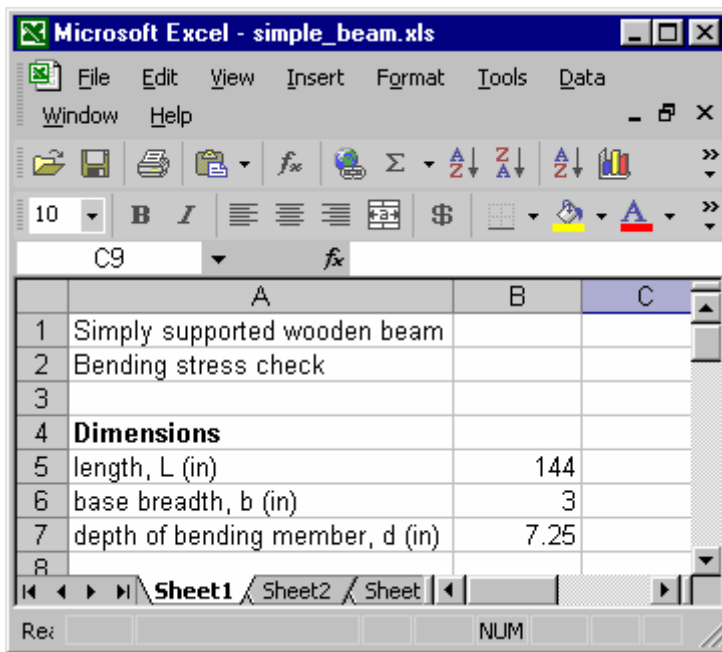
We'll be creating spreadsheets to illustrate the concepts as we move along. To get the cell "A4" to have a bold face font, simply click on that cell and then click on the bold face "**B**" on the menu bar at the top. Before we move on with formulas, let's look at the basic operators and the order in which they are handled by the spreadsheet. When you're done, save the sheet as whatever name you like.

Basic Operators

There are four categories of operators in Excel. These are mathematical, logical, text, and reference. In Engineering we are mainly concerned with mathematical operators, but it helps to understand the others as well.

The basic mathematical operators in Excel are:

+ (addition)
- (subtraction)
* (multiplication)
/ (division) (example: 4/5 is four divided by five)
^ (exponential) (example: 2^3 is two cubed)
 % (percent) (example: 20% is equivalent to 20/100 or 0.2)

The basic logical operators are:

=   means equal to, and is also used to start all formulas
>   means greater than
<   means less than
>=   means greater than or equal to
<=   means less than or equal to
<>   means not equal to

One text operator is the ampersand, "&" which is used to concatenate text strings together.

And finally, the reference operators which are the colon, the comma, and the space.

The colon is used to define a range of cells, for example A1:A5 would define the block of cells including A1, A2, A3, A4 and A5.

The comma is used to combine references together in various ways, and to separate values or portions of formulae inputs.

A single blank space between references is used to define the intersection of the two references, generally two ranges (as defined by the colon - for example A1:A5 A1:B5 would define values found in the intersection of these two ranges, effectively the range A1:A5 in this case).

Order of Operations:

It is important to understand how spreadsheets process the operators, so mistakes are not made in the writing of formulas. The order is as follows, and it proceeds left to right if operators have equal priority:

Operator	Processing Priority
Colon ":"	1
Single space " "	2
Comma ","	3
Negation, like "-1"	4
Percent "%"	5
Exponentiation "^"	6
Multiplication and Division "*" "/"	7
Addition and subtraction "+" "-"	8
Ampersand "&"	9
Logical Operators "<, >, <=, >=, <>"	10

Keep these orders in mind when writing formulas. If in doubt, you can always place operations in parenthesis to ensure they are processed first. Items in parenthesis will be processed from inner to outer layers, just like in ordinary mathematics, and will take precedence over the ordinary order of operations.

Entering a Formula

```
Microsoft Excel - simple_beam.xls                    _ □ ×
  File   Edit   View   Insert   Format   Tools
  Data  Window   Help                              _ 6 ×

  [toolbar icons]   10 ▼  B I ≡ ≡ ≡

         A3            ▼      fx
                A                           B
 1   Simply supported wooden beam
 2   Bending stress check
 3
 4   Dimensions
 5   length, L (in)                        144
 6   base breadth, b (in)                    3
 7   depth of bending member, d (in)      7.25
 8
 9   Physical Properties
10   Young's modulus of elasticity, E  1600000
11   allowable fiber stress in bending,    875
12
13   uniform load (lb/in)                   10
14
15   Calculated Values
16   section modulus, S (in^3)         26.28125
17   resisting moment, Mr (in-lb)      22996.09
18   max bending moment, Mb (in-lb)       25920
19   total vertical load, lb               1440
20
21   Bending stress ok? (Mb<Mr)   NO
    Sheet1 / Sheet2                            NUM
```

A formula is begun by entering an equals sign "=" in a cell, followed by the contents of the formula. Before we do that, lets enter a few more values. Add the values as shown here in cells defined by the range A9:B13. (The cells in this range are A9, A10, A11, A12, A13, B9, B10, B11, B12, and B13) by clicking each cell and entering the information.

We now have the information we need to do a few calculations. First enter the text values as shown in cells A15:A21. Now go to cell B16. You can move directly to any cell by clicking in the active cell box at the top left of the spreadsheet (it currently displays "A3") and typing the destination cell address. You can also use the arrow keys to move around, or your tab key to move across. Or, just click in the cell.

We want to calculate the section modulus which is defined by the formula:

$$S = \frac{bd^2}{6}$$

In our spreadsheet, the value for the base is entered in cell B6, the depth is in B7, end we ant the result displayed in cell B16. From cell B16, enter the following equation:

=B6*B7^2/6

(Hit enter when you are finished, or click the green check mark next to the cell display box up top). The order of operations will ensure that the exponent (depth squared) is executed first, then the multiplication and division will proceed from left to right, so first the base will be multiplied by the depth squared, then that result is divided by 6. (This may seem trivial, but a mistake in understanding the order of operations can easily cause an error in the calculated result). This should give the result of 26.28125.

Next, lets enter the simple equation for the resisting moment, Mr (the ability of the beam to withstand bending stress) which is the section modulus X allowed fiber stress for the wood. Move your cursor to cell B17 and enter the formula: =B11*B16. Hit enter, then enter the formula for the max imposed bending moment, which for this case of a simply supported beam is defined by the formula:

$$Mb = \frac{wl^2}{8}$$

Where w = the uniform load in lbs/inch, and l = length in inches. This formula is entered in cell B18 as: =B13*B5^2/8. After you hit enter, add the formula for the total vertical load on the beam which is

simply the uniform load multiplied by the length, in this spread sheet that corresponds to the formula =B13*B5. You should get the result of 1440.

Now how do we know the bending stress is ok? If the bending moment, Mb is less than the resisting moment, Mr, (provided, of course than any applicable safety factors have been incorporated into the allowed fiber stress value), then the beam is ok for bending stress. In this case, it is not ok, and we want the spreadsheet to look at the two values, make a decision, and display "YES" if Mb is less than Mr, and "NO" is Mb is not less than Mr. To do this we can use the IF function and the logical operator "<" for less than. The logical test in cell B21 looks like this:

$$=IF(B18<B17,"YES","NO")$$

The format for this function is: IF(logical_test, value_if_true, value_if_false). In this case B18 is not less than B17, so the logical test returns "FALSE" and the string "NO" is returned and displayed in the box.

Part of the power of a spreadsheet lies in the ability to tweak input parameters and instantly see the result on the calculated value. In this case, try increasing the value for the depth of the beam until a result of "YES" is achieved in the output box. While we do this, lets explore a handy feature which allows you to look at separated areas of a spreadsheet simultaneously. Look at the scroll bar on the right. Just above the "up" arrow, there is a very narrow horizontal bar. Click and drag that bar down to "split" the worksheet. When you do this, you will see you now have two scroll bars on the right and you can move the contents of each window of the spreadsheet as you see fit. This is a very useful feature when using large spreadsheets, especially if you want to see how changing one or more values affects a particular calculation result somewhere else on the spreadsheet. Try splitting the
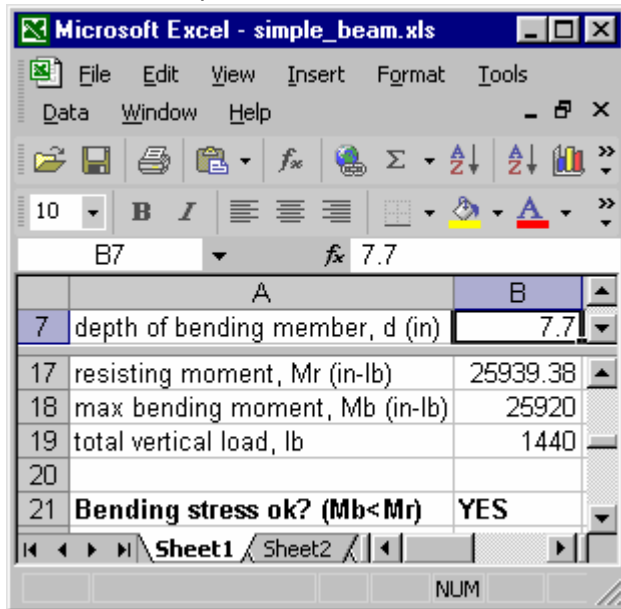

spreadsheet and scrolling so we mostly see just what we are interested in at the moment, which is the input depth value, and the output of "NO" or "YES". Adjust the spreadsheet so it looks something like this:

Now you can vary the entered value for B7, the depth, and see the impact on the decision and on the bending moment. Go up by 0.1 each time until you get a "YES".

This was a manual process, adjusting the value until we got the result we wanted by means of a logical test. There is another handy feature called "Goal Seek" which will automatically home in a desired result by varying input parameters. This can be a powerful optimization tool when applied creatively. Let's see how it would work in this case.

We know we want the resisting moment Mr in cell B17 to be at least the bending moment imposed of 25,920 shown in cell B18, and we want to vary the depth in cell B7 to do it. So go to the menu bar up top, click on tools, goal seek, and a dialog box pops up. Enter the cell address B17 in the "set cell" field, set the value to 25920.1, and in the by changing cell field enter the cell address for the depth, B7. Hit "OK" and watch what happens. The spreadsheet solves for the value that meets the goal you set. Next we'll look at some of the functions of interest to engineers.
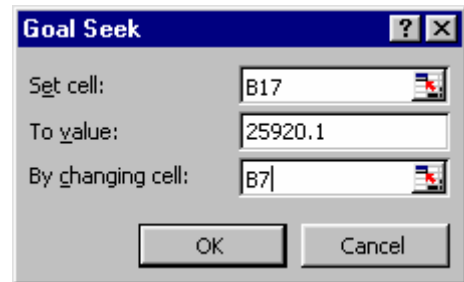
Introduction to Math Functions
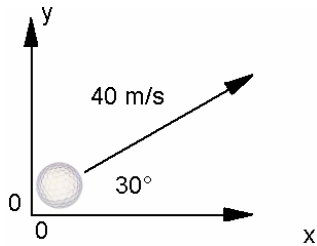
Virtually all of the functions you can perform with your scientific or engineering calculator can be performed on a spreadsheet. The exact syntax of a function varies slightly depending on the function but in general the format is: =FUNCTION_NAME(Argument1, Argument2, etc). Most functions are fairly straightforward and self-explanatory. As an example, let's learn about a couple of basic functions and at the same time learn how to place a chart in a spreadsheet - by looking at the trajectory of a simple projectile. Let's say Joe is on Earth and hits a 0.045 kg golf ball from the ground at an angle of 30 degrees from horizontal and with an initial velocity of 40 meters per second. Let's graph the trajectory and find how long it takes to reach it's zenith, how high it goes, and how far it goes. Lets also set up our spreadsheet so we can find the x and y position at any point in time. We'll assume no friction, spin or lift effects and that the travel is in a vertical plane. (And no slice or hook).

From projectile motion equations, we know the following, which we will build into our spreadsheet for trajectory of a golf ball:
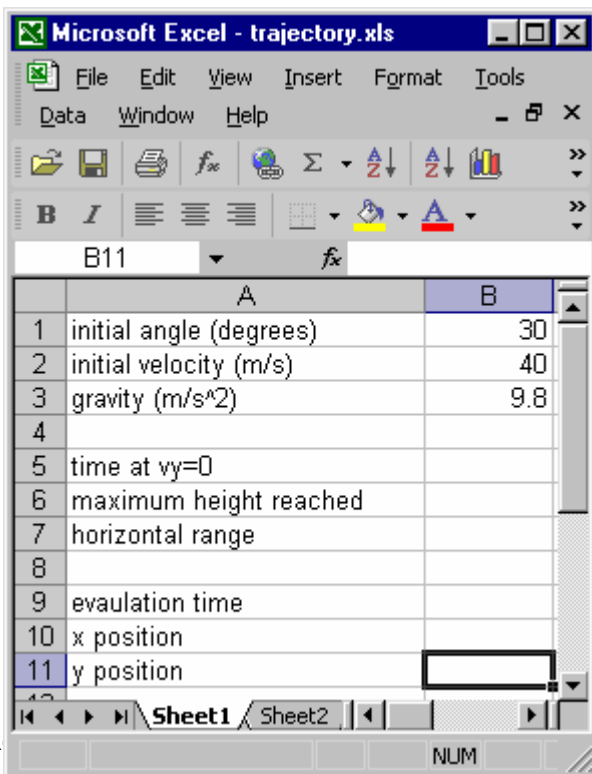
$$t = \frac{v_0 \sin \theta_0 - v_y}{g} \quad (1)$$

$$y = (v_0 \sin \theta_0)t - \frac{1}{2} gt^2 \quad (4)$$

$$R = \frac{v_0^2}{g} \sin 2\theta_0 \quad (2)$$

$$y = (\tan \theta_0)x - \left(\frac{g}{2v_0^2 \cos^2 \theta_0} \right) x^2 \quad (5)$$

$$x = (v_0 \cos \theta_0)t \quad (3)$$

(Where R is the range (in x), θ_0 is the initial angle, and v_y is the y component of the velocity vector).

We will be using the excel functions of SIN, COS and TAN in our equations. Open a new spreadsheet to follow along as we enter the equations and functions.

Enter text into column A and B until your new sheet looks like this one. Resize the column A to fit as before.

We are interested in finding the maximum height, which will be when the y component of the velocity is zero. We'll first find the time to reach this point by substituting zero for v_y in equation (1), and then entering that form of the equation in cell B5. The equation will look like this:

=B2*SIN(B1)/B3

We enter this and get -4.032…what happened? Did we invent a time machine? No - we have the wrong units for the angle. Excel uses radians for angle calculations, not degrees. We have a couple of choices - we could simply convert to radians in our formula by multiplying by π/180, or we can convert using the radians function built into Excel. Let's do the latter. Change your formula (click the box it's in and edit in the edit box up top. then click the green check to finish it) so it looks like this:

$$=B2*SIN(RADIANS(B1))/B3$$

We should now get the result of 2.04….seconds. Let's clean up the formatting a bit. Click the column heading for column B to select the whole column. Then click on "format" and "cells" on the menu bar, pick "number" and enter 3 for the number of decimal places, and hit "OK". Let's also right align the column, which can be done on the tool bar by selecting the column and hitting the right align button which looks like this: .
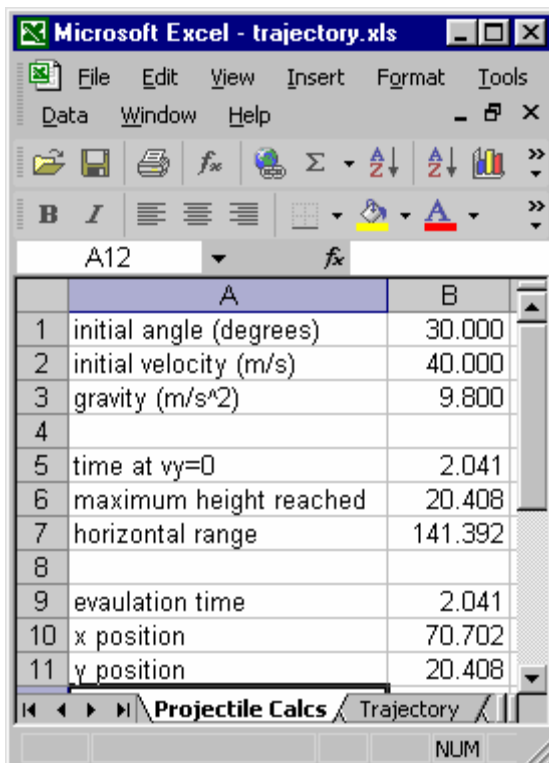
For the maximum height, we'll use equation (4), substituting in the time value we just calculated. The formula we enter in cell B6 will look like this:

$$=B2*SIN(RADIANS(B1))*B5-0.5*B3*B5^2$$

and gives a maximum height of 20.408 meters. Finally, let's calculate the horizontal range of the drive, using formula (2) in cell B7. (By the way, when entering the formulas, one can simply click on the cell containing the variable that needs to go into the formula, on the fly as the formula is written. Try this method as you enter this formula, clicking on cells B1, B2, and B3 instead of typing in the cell addresses. You'll have to click back in the cell contents editing area at the top to get back to editing the formula after clicking outside of it. The formula looks like this:

$$=(B2^2/B3)*SIN(RADIANS(2*B1))$$

A 141.392 meter drive is the result.

Now write in the formulas for x and y position as a function of time (shown above as formulas (3) and (4). These go in cells B10 and B11. When you are done, your spreadsheet should look like the one shown here. Start off with an evaluation time of 0.5 seconds. Try a few other values for the time to see how it affects the results. Try 2.041 to check the results versus those calculated earlier - they should match.

We've looked at some of the trigonometric functions in this example. To access other functions including math functions in Excel, simply click on this icon and select a category. The dialog box will display the available functions in the category, and when you pick one, the syntax will be displayed as well. By selecting a function you can insert it in your cell.

Now let's move on to set up a chart (graph) to display the trajectory in visual format, and to learn a bit about charting in Excel.

Creating an Embedded Chart

Before we add a chart, we
have to set up a data range
of values to chart. In this
case, we are going to be
charting horizontal x values
versus vertical Y values on
even time intervals of 0.2
seconds. We'll start by
creating a column to use for
the input of the time values,
which includes the numbers
0, 0.2, 0.4, etc., up to 2.2.
We could just type in the
values in a column, but
there's a simple way to get
the numbers we want with a
formula, and relative
addressing of cells. At the
same time we'll learn a bit about using multiple spreadsheets, and relative versus absolute
addressing of cells.
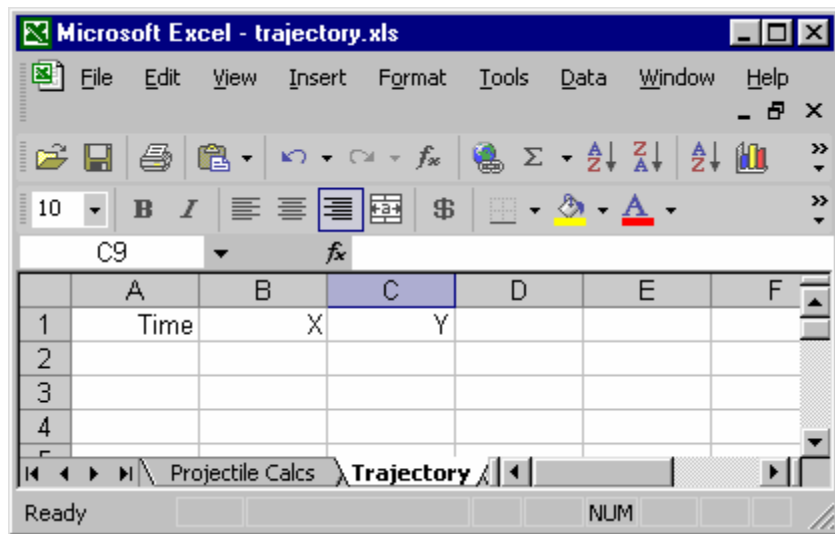
Lets rename our top spreadsheet, call it "Projectile Calcs". To do this, double click the tab at the
bottom that says "Sheet1" and when it's highlighted, just type the new name.

Now, activate the second sheet by clicking it's tab. You should see a blank sheet. Then double click
the tab and rename the second sheet "Trajectory". If you need to, you can move the tabs back and
forth by clicking and dragging them, or use the arrows on the bottom of the scroll bar to move back
and forth in the spreadsheet. You can use the arrows at the far left of the scroll bar to move between
sheets.

Now enter the headings "Time", "X" and "Y" in the top three cells going left to right (A1:A3). Highlight
the first three columns, and right align them as before. Now enter the value "0" in cell A2. Then, click
in cell A3, and enter the formula "=A2+0.2". Now we can use the fill feature and relative referencing to
get our list of numbers which increments by 0.2. What we'll do is to copy the formula we just wrote in
A3 down to cells A4 through A13 (A4:A13). to do this, click on cell A3, and drag the cursor down until
the cells range A3:A13 is highlighted. Once that is done, click on "Edit" in the menu bar, then "Fill"
and "Down". Excel fills in the blank cells with a formula which holds the same relative reference to the
cells around is as the one being copied. Hence, each formula increments by 0.2 because it
references the cell above it for the first number in the equation in the cell.

Go ahead and format the three columns to three decimal places as before. Now we want to use the
formulas on our first spreadsheet to calculate the X and Y values for the second spreadsheet. Let's
copy the formulas from the first to the second sheet.

Activate the first spreadsheet "Projectile Calcs" by clicking the name tab. Go ahead and select cell
B10, do "Edit" , and "Copy" from the menu bar (or CTRL +C) and then move back to sheet 2,
"Trajectory" and click on cell B2 and then do "Edit" and "Paste" (or CTRL +V). Whoa… what's this
mean?

$$=\#REF!*COS(RADIANS(\#REF!))*B1$$

Excel is telling you that it has found an invalid reference. Apparently, this formula referenced itself (since it has a "B2" in the formula, and it is located in cell B2) and this is a circular reference.

We simply need to edit the formula to use the values on the first sheet (Projectile Calcs) for the initial velocity and angle, and use the values from the Trajectory sheet for the time variable. Edit the formula in cell B2 so it looks like this…(you can cut and paste from this text if you like)

='Projectile Calcs'!$B$2*COS(RADIANS('Projectile Calcs'!$B$1))*A2

The reason we need "$B$2" instead of "B2" is because we want this to be an absolute reference - which means that when it is moved or copied on the spreadsheet, it will continue to refer to the same address, like an anchor. If you don't do that, Excel will assume relative addressing, and will change the address to reflect the same relative positional relationship, That sounds complicated! But it's really quite simple. A relative cell reference just looks to a certain cell relative to the home cell (for example, 2 over, 3 up in the spreadsheet. If you move or copy cell contents with a relative address, they will continue to refer to the cells 2 over and 3 up from their new position.

Now we can use the "Edit". "Fill", and "Down" commands from the menu bar to copy the formula we just created, with absolute addressing, down to calculate the x displacements for each time value, the same way we did for the time value incrementing. Go ahead and highlight range B2:B13 and fill in the formulas. Note that we kept the relative addressing for the time values (A2:A13). We can use the same method to enter the formula for the Y displacement.. That formula you enter into cell C2 will look like this:

='Projectile Calcs'!$B$2*SIN(RADIANS('Projectile Calcs'!$B$1))*A2-0.5*'Projectile Calcs'!$B$3*A2^2

Which you can fill down to complete this step.

Now that we have some data values, we're ready to add a chart. But, hey - the ball is still in the air at 2.2 seconds - lets used the "Edit" "Fill" "Down" to add values to our table - all the way down to row 23, so it looks like this. (Do this by clicking and dragging to highlight cells A13:C23, then do the "Edit" "Fill" "Down" command.
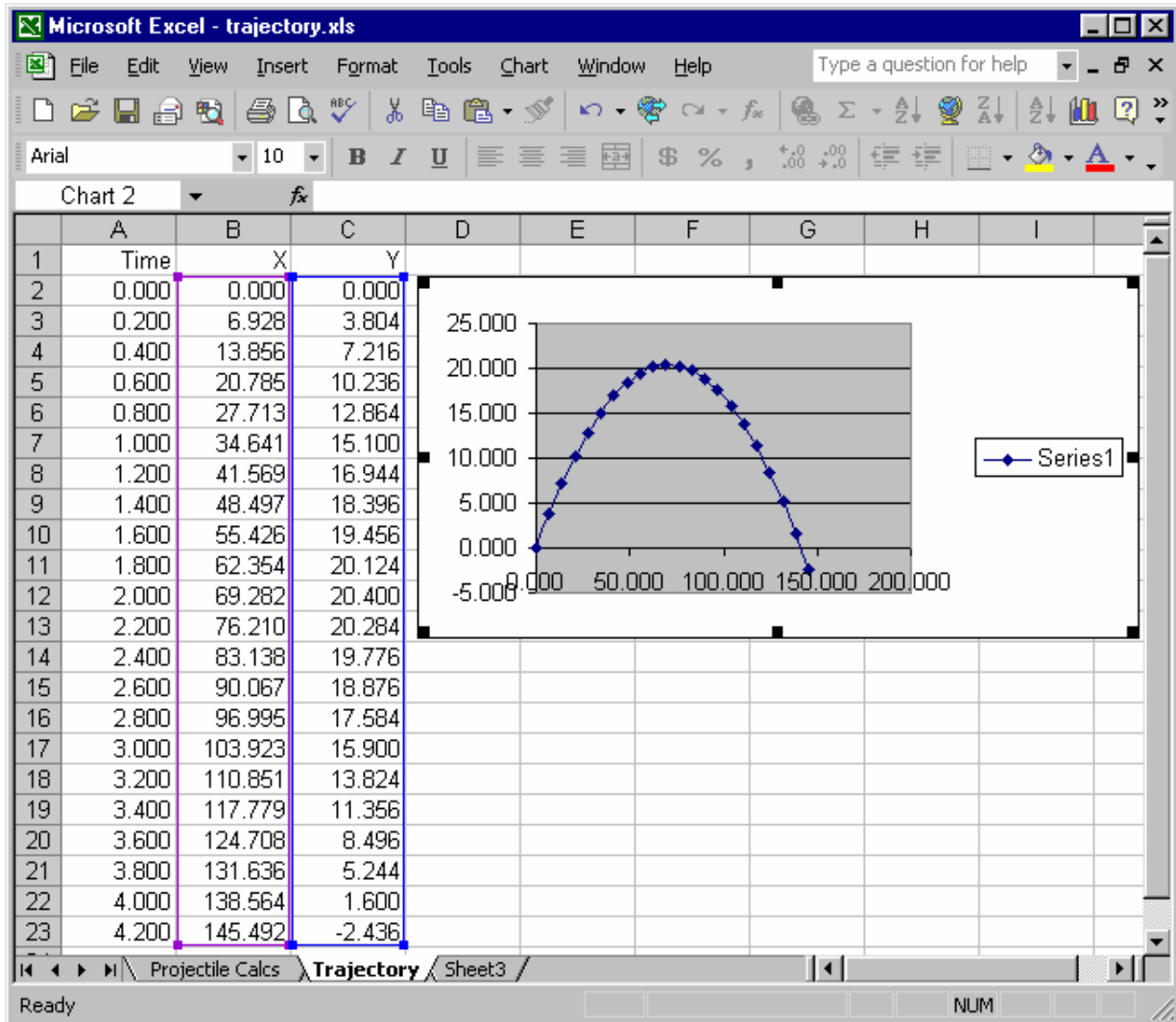
Make sure the range B2:C23 is selected. To add the chart as shown, go to the chart button on the tool bar, click it, then pick X-Y Scatter, and the one with the curved lines and points. Pick next, next, then finish, then you can drag and position the chart as you like. We'll do a bit of formatting to make the chart more presentable. In general, to format a chart, you can click on the item you want to format, then choose options for it. For example, let's get rid of the values to the right of the decimal point on the axes. Double click on the x-axis, pick "number". enter "0" for the decimal places, and close that. Then do the same on the y-axis. Then right click in a blank area of the chart and pick "chart options". You can experiment with this, adding titles, data labels, etc. We've added a title to the chart, and the x and y axis. If you again right click, and pick "source data" you can rename the series legend. We named it "path points".

You can stretch the chart to any size you like by grabbing the dark rectangles on the sides or edges and then clicking and holding, and then dragging the cursor. You can also copy and paste the chart to another spreadsheet in the workbook, or place it in it's own worksheet. Lets copy and paste it to the "Projectile Calcs" sheet so we can change some values and see how it affects the trajectory. Select the chart and hit CTRL+C, then select the tab for "Projectile Calcs" and hit CTRL+V to past it on that sheet. We've played with the formatting a bit to get this look - you can experiment with formatting to change the look of the chart any way you like.

Try entering some different values for the initial angle, or initial velocity, or both to see how you instantly get a graphic representation of how these changes affect the trajectory. Here we have changed the initial angle to 20 degrees:
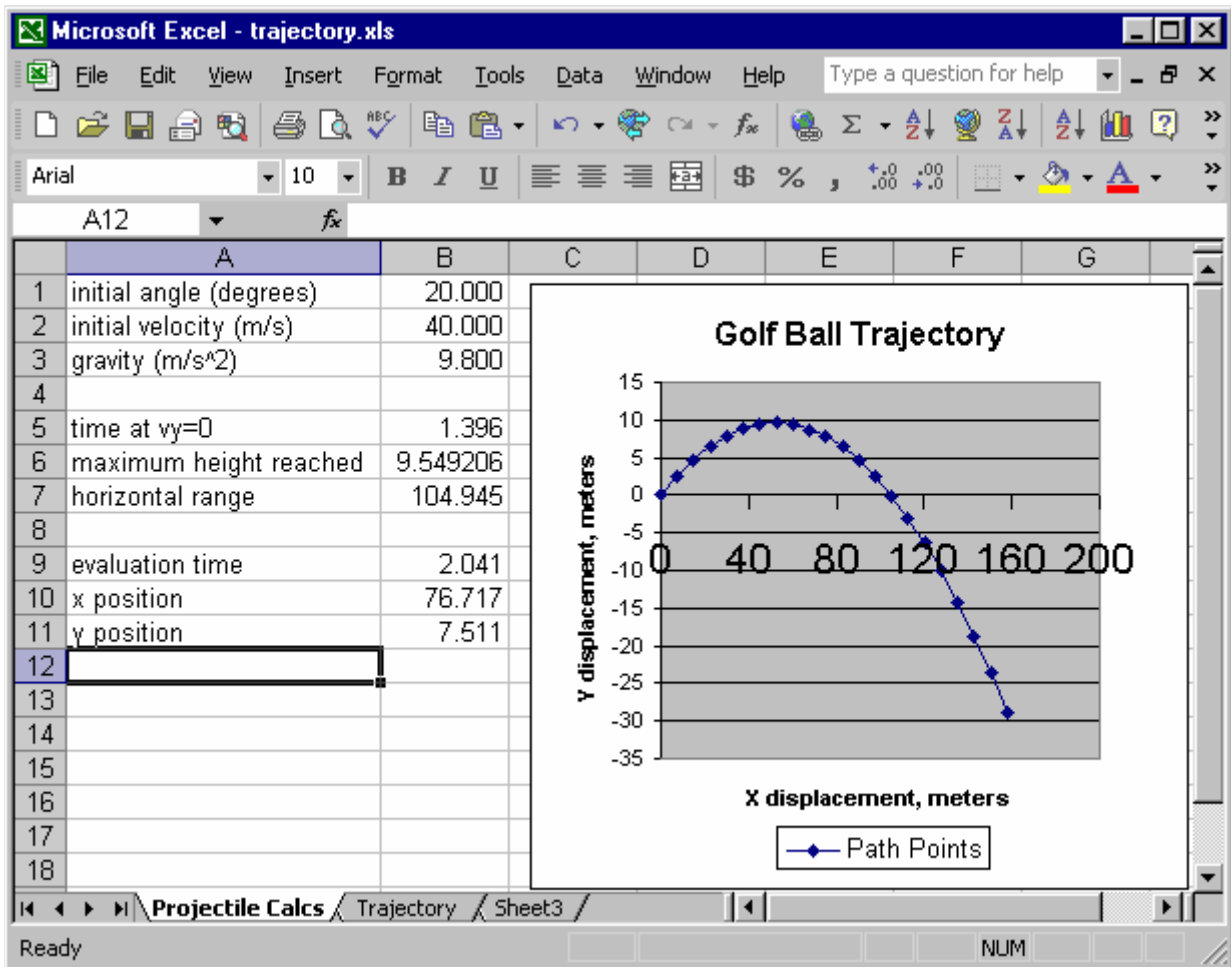
Introduction to Statistical Functions

Continuing our discussion of functions, lets do an example where we employ the use of some statistical functions. For data, let's use data from a sample of production parts. A sample of 25 parts was analyzed from a production run of 500 parts. The yield strength values for these 25 sample parts is shown in the sample spreadsheet, which you can open by clicking here, or you can build yourself from scratch.

We will look at a few of the many statistical functions included in Excel, in this case the AVERAGE function, the STDEV function, and the NORMDIST function. We'll use these functions to look at the sample data and predict how many parts out of the production run will fail the test criteria of a minimum yield strength level.
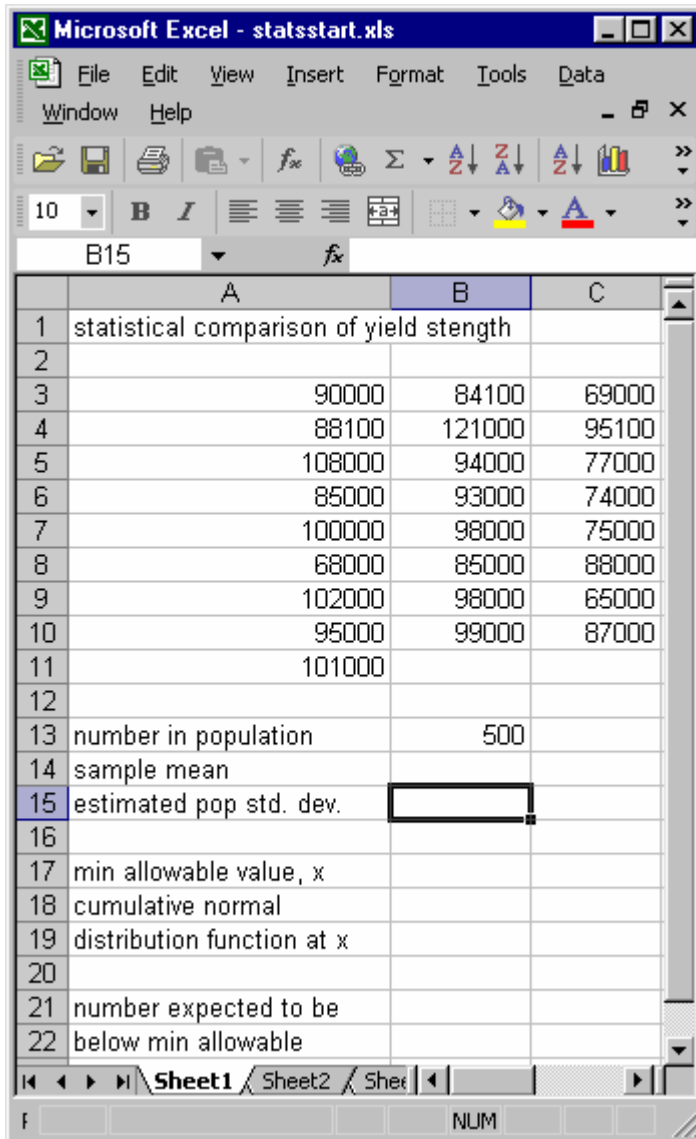
We start by calculating the sample mean, or average. In cell B14, enter the formula "=AVERAGE(A3:C11)". Note that you can select the range by boxing it with your cursor (click and drag). Also note that Excel does not enter zero values for the empty cells in the incomplete range.

The average value is calculated and displayed. It should be 89572.

Next, we want to know the estimated standard deviation of a population based on this sample. We'll need this value to find out how many we would expect to be rejecting. Note that a normal distribution is assumed here.

For the standard deviation, enter the formula "=STDEV(A3:C11)" in cell B15. This is the estimated standard deviation for a population based on this sample deviation and sample size.

Now we can use the power of statistics to determine how many of the population would be rejected because they fall below our test value, which we set to a minimum allowable yield strength of 69000 by entering that value in cell B17.

In cell B19, enter the formula for finding out the cumulative normal distribution value by entering " =NORMDIST(B17,B14,B15,TRUE)". Note that the inputs include B17 for the "x" value, B14 for the mean, and B15 for the standard deviation of the sample. The TRUE flag tells the formula to return the cumulative value, or the sum of everything under the normal distribution curve from negative infinity up to our test value of 69,000. This returns a decimal value from 0 to 1, in this case 0.0606… This is the fraction of our test population which will be rejected, so in cell B22 we enter the formula " =B19*B13" which multiplies that fraction by the number in the population, 500. Thus we get the result of 30.33 rejected parts in the population, just over 6%.
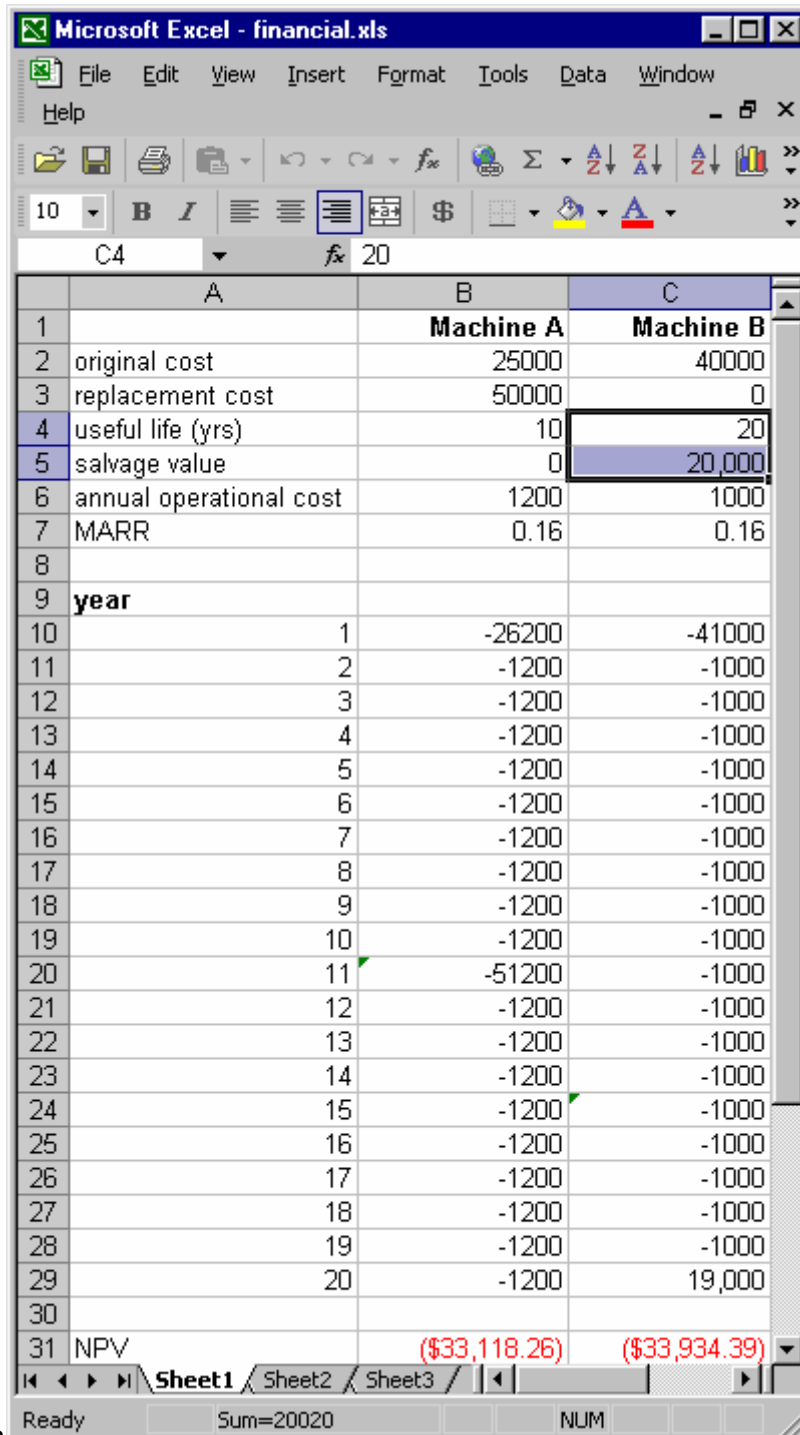
Financial Functions

Engineering often involves decision making processes where financial impact is a major factor, if not the most important one. Spreadsheets provide excellent tools for engineering economics type problems involving cash flows, depreciation, time value of money, etc. In this section we'll use a spreadsheet to make a purchase decision based on the method of Net Present Value or Present Worth-Cost).

Problem: A company must decide which of two machines to purchase. One machine (A) has a useful life of 10 years, costs $25,000, and has no salvage value. It is estimated that it will cost twice as much to replace it in 10 years. Another machine (B) has a useful life of 20 years and costs $40,000, and has an estimated salvage value of $20,000. Annual maintenance and operation costs are $1,200 for machine A and $1000 for machine B. Production capacity is the same for the two machines. Which machine is a better choice, given a minimum attractive rate of return (MARR) of 16%, based on net present value?

Method - Net Present Value, or Present Worth-Cost:

In this method, all cash flows for each alternative are brought to their present worth-cost by discounting them by the MARR, then they are compared to one another. Whichever alternative has a least negative present worth-cost will be the better option. We will assume that machine A is replaced after 10 years, so our time period for comparison is equal for both options - 20 years.

Enter the text and values shown in cells A1:C9. For the year you can enter the numbers, or use a formula and copy it down as we did in a previous example. Then enter formulas or values for the two columns of cash flows. Each year there is a negative cash flow due to operational costs, and purchase or replacement costs. For machine B there is a positive cash flow in year 20 due to the salvage value.

In cell B31 we compute the NPV or net present value of the cash flows in the range B10:B29 according to this formula:

=NPV(B7,20,B10:B29), and in cell C31 we similarly use the formula:

=NPV(C7,20,C10:C29).

The result of the calculation shows that machine A is a slightly better option. Note that in this format, the negative values or shown balance sheet style, with negatives shown in parenthesis.

Microsoft Excel - financial.xls

C4 = 20

	A	B	C
1		**Machine A**	**Machine B**
2	original cost	25000	40000
3	replacement cost	50000	0
4	useful life (yrs)	10	20
5	salvage value	0	20,000
6	annual operational cost	1200	1000
7	MARR	0.16	0.16
8			
9	**year**		
10	1	-26200	-41000
11	2	-1200	-1000
12	3	-1200	-1000
13	4	-1200	-1000
14	5	-1200	-1000
15	6	-1200	-1000
16	7	-1200	-1000
17	8	-1200	-1000
18	9	-1200	-1000
19	10	-1200	-1000
20	11	-51200	-1000
21	12	-1200	-1000
22	13	-1200	-1000
23	14	-1200	-1000
24	15	-1200	-1000
25	16	-1200	-1000
26	17	-1200	-1000
27	18	-1200	-1000
28	19	-1200	-1000
29	20	-1200	19,000
30			
31	NPV	($33,118.26)	($33,934.39)

Sheet1 / Sheet2 / Sheet3 /

Ready   Sum=20020   NUM

Spreadsheets are a very flexible way to assess financial impact of cash flows which may not be immediately obvious. The real power comes from the fact that various options may easily be compared and contrasted, and adjusted on the fly.

Another highly useful financial formula is for internal rate of return, or MIRR. The function MIRR considers both the rate of return on invested money, as well as the cost of borrowed funds. For this formula you must have at least one positive and one negative cash flow, and the use is similar to the use of NPV. Please explore the use of MIRR on your own as an exercise.

Logical Expressions

Logical expressions use logical functions, and are generally used for evaluation and decision making. The logical functions supported in Excel are: AND, FALSE, IF, NOT, OR and TRUE. The TRUE and FALSE functions simply return the value "TRUE" or "FALSE". The NOT function reverses the logical state of the argument. The AND function returns the value "TRUE" when all arguments are true, otherwise it returns "FALSE". As expected, the OR function returns the value "TRUE" if any of its arguments are true, and otherwise returns the value "FALSE" (when all arguments are false). The IF function performs a logical test, then returns a specified value if the test is true, and another value f the test is false. As an example, let's look at the IF function. The format is: =IF(test, value_if_true, value_if_false). Both "value_if_true" and "value_if_false" can be another formula.
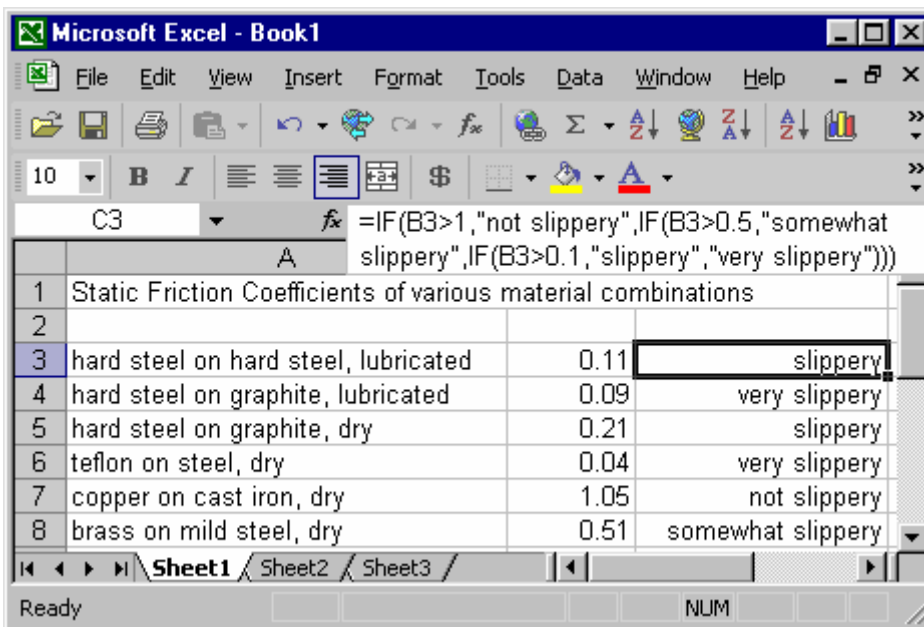
Here we are performing a nested logical test. If the value in column B is greater than 1.0, it is categorized as "not slippery". If it is less than 1.0, therefore false, then the value of the next formula is used for the "value_if_false", so the function next tests to see if the B column is greater than 0.5, in which case it is assigned the value "somewhat slippery". This logic continues until the final test, categorizing each value according to how slippery it is. The result of the logical test may be passed on to another test simply by using the cell reference in the next function or formula.

Engineering Functions

Engineering functions, as Excel calls them, are a bit misleading. While all of the math, statistical, logical, and many other types of functions clearly are useful to engineers, Excel singles out certain ones as seemingly being useful *only* to engineers. Most of these functions involve complex numbers, conversion of binary and hexadecimal numbers, and Bessel functions. If your calculations require frequent manipulations involving complex numbers, and conversions of binary and hex, feel free to explore these functions - which go beyond the scope of "spreadsheet basics".

Data Tables

In Excel, data tables are used to evaluate formulas for multiple values of the same input variable. Data tables may be either one-variable or two variable types. For example, say you wanted to determine the resonant frequency of a series RLC circuit for a variety of commercially available inductors and capacitors. Let's say we have five inductors with inductances of, 20, 40, 60, 80 and 100 μH and five capacitors of values 1, 2, 3, 4, and 5 nF. The formula for the resonant frequency (in Hz) for this circuit is:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

To create a two variable data table first we create a basic spreadsheet with the variables on the left, and the formula to the right. We are going to create an array, with the capacitances in the left column, the inductances in the top row, and the formula at the top left corner of the array. It looks like this:

Notice that we have entered the values in scientific notation directly. Also notice the use of the exponent in combination with the fraction (0.5) to represent square root. (We could have used SQRT()). Also notice the use of the PI() function, which returns PI to 15 digits. We have entered the formula shown on the formula bar in cell C1. (The values in B2 and B3 are arbitrary test values).

Now to create a two variable data table, we need only select this array (cells C1:H6) and go to the menu, select "Data" and "Table", at which point we are prompted for the row input cell and the column input cell. For the row input, we want to use the inductances, and the original reference to them for our formula is in cell B3. For the column input, we want to use the capacitances, and the original reference to them is in cell B2. So we specify B3 for the row input, and B2 for the column input, and click "OK".

We now have an array which displays the calculated the values for the resonant frequency for each combination of these inductors and capacitors.

For a one-variable data table, simply leave out the row of values, use one variable, and follow the same procedure.

Sorting Data

The sorting functions in excel are geared to sorting by column, Once data is in the spreadsheet, you may sort on anywhere from one to four columns by a variety of criteria. In order to sort, it is best to create a list. A list, in Excel, is simply rows and columns of data, organized usually by column, and the columns have a label. The column label is entered in the cell at the top of the column. Here is a sample list to sort.

To sort the list by the first column, you can select a cell in the column, then select a cell in the first column, then pick "Data" and "Sort" from the menu bar, and you then see the first column label as the sort variable. You may sort in ascending or descending order, and by one two or three columns. If
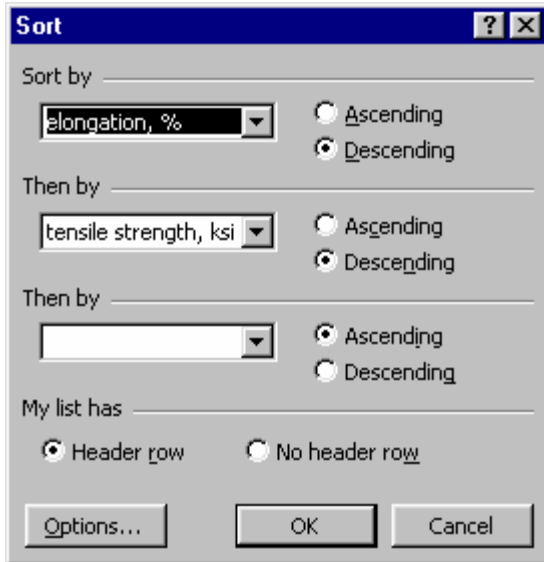
you sort by more than one column, the sort will be done sequentially. For example, if we want to sort descending by elongation, then by tensile strength, our dialog box would look like this:

After performing this sort, our data table looks as shown below. You may by up to three columns in this way. If you want to sort by four columns, pick a cell in the table, then "Data" and "Sort" and then just sort on the least important column of the four, close out the dialog box, then re-sort by the additional, more important three columns last.

You may also sort by rows by going into the options menu from "Sort" dialog box and select the option to sort from left to right.
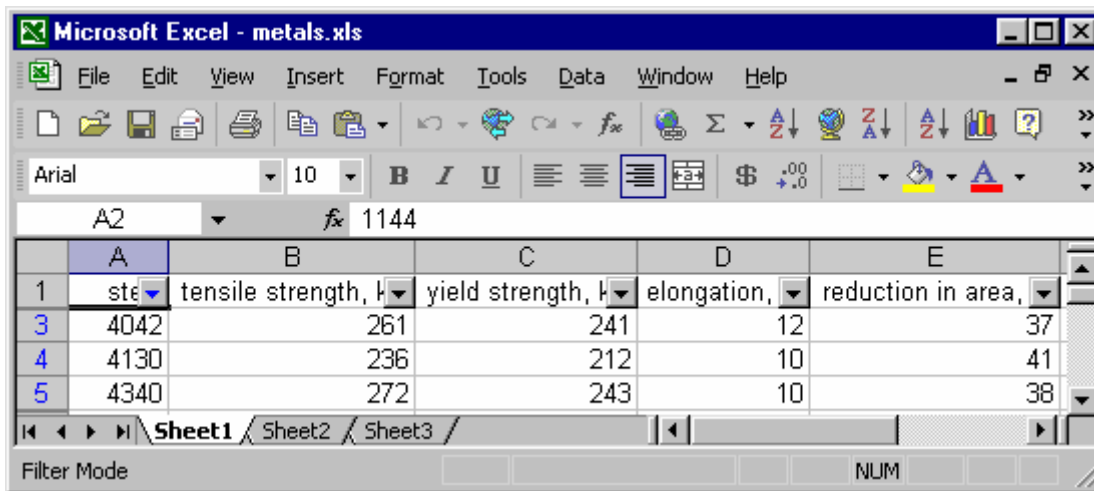

Filtering Data

Another way of manipulating data is by filtering it. Filtering is similar to sorting, but instead of re-ordering the rows of data, Excel will simply not display data that doesn't meet the filtering criteria. Using the same spreadsheet example as the last one, we can set up each column to hide values - for example, we could only display 4000 series steels by filtering the first column with a logical expression. Pick a cell in the first column, then pick "Data", "Filter" and "Autofilter" and "OK". After turning on the autofiltering, each column label will have a drop-down arrow next to it. If you select that arrow, you can apply filters to the rows based on the values in that column. In this case, pick "custom" and add a logical expression to select values greater than or equal to 4000 and less than 5000. These choices are made in the dialog box that comes up for custom filtering, which looks like this:
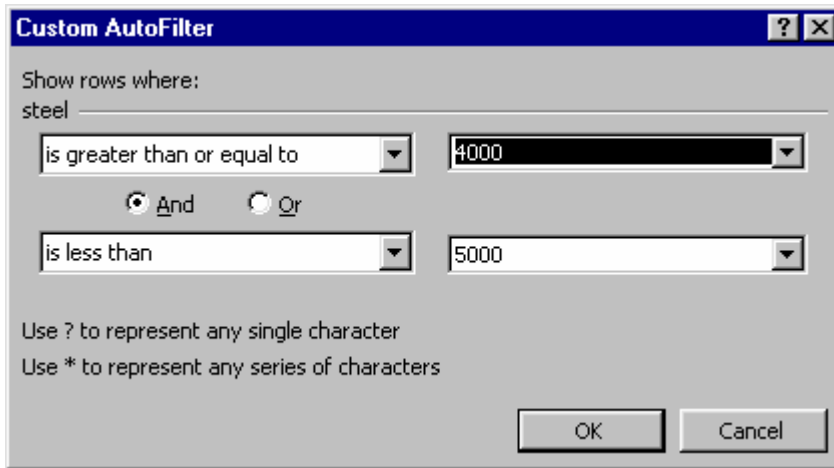
And the list with this filter applied now looks like this:

More advanced filtering is also available where a criteria range may be defined with multiple entries, complete and partial text string matches, etc. For more on this consult the help features of Excel.

Excel Web Basics

Copying and Pasting From Web

Copying and pasting static data from the Web is a straightforward process. Simply highlight text or table data on the web page, and use the "Paste Special" command from the "Edit" menu in Excel. If you pick "text only" you will retain the rows and columns of tabular data when you paste it.

Web Queries

You can open web queries in Excel which will insert data tables from a URL you specify. These web queries may be made static, or refreshable. With static queries, what you paste is what you've got. With refreshable web queries, you may update them any time to reflect the current values that appear on the URL specified in the web query. On example of how this may be used is tracking real-time data and analyzing it. This could be published spreadsheet data for a project group to all reference

and use in their local spreadsheets, it could be stock prices, temperatures, any dynamic information which is available on the web can be imported and kept current on a local spreadsheet this way.

To insert a table from a web page, Pick a cell on your spreadsheet, then pick "Data" and "New Web Query". You will see a dialog box which allows you to enter a URL which you may copy and paste from the address bar in a browser, or simply type in. After specifying the URL, the web page will appear in the query dialog box, and you can select tables to insert by picking the arrow symbol next to the table (it turns to a check when selected.

After pasting the data on the spreadsheet, you may update it by picking "Date" and "Refresh Data" from the menu bar. Any graphs or dependent formulas you create will also be updated when you refresh the data.

Publishing Workbooks on the Web

If you have a website you have write access to, you may publish your workbooks as interactive or non-interactive spreadsheets as part of you web pages. Interactive workbooks will allow users to edit and manipulate the cell contents, formatting, formulas, etc. Non-interactive workbooks will be essentially "read only" views of the workbook, with active tabs for switching between sheets in the workbook. To do this, use "Save as" from the menu bar and pick "Web page from the type options. Then when you save, choose whether you want interactivity or not.
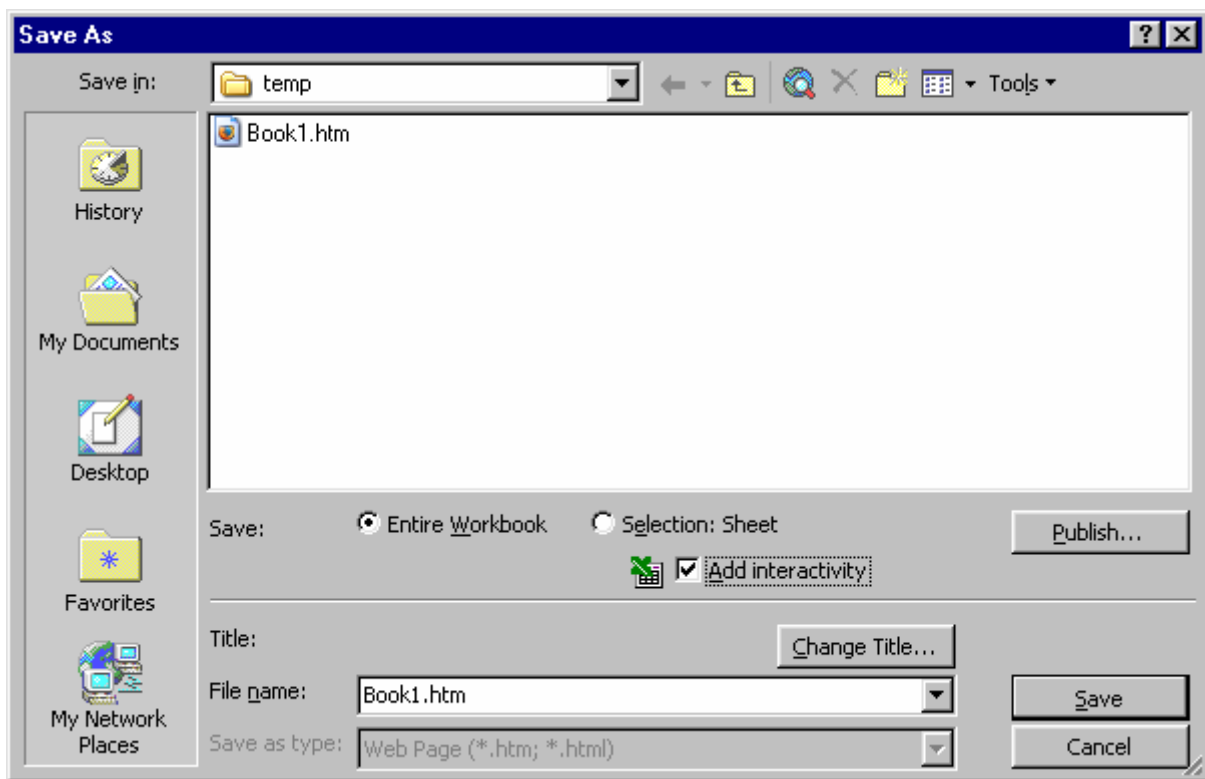
Once you have save the page as HTML, you can insert the source code using a web page editor, or post the entire page to a website in the usual manner.

Formatting

A few basics on formatting are presented here, feel free to dig in and explore this area on your own. We'll briefly cover row and column sizing, text alignment, fonts, text size, cell borders, and cell fill colors here. Most of these functions are implemented simply by selecting the cells you want to format, picking the drop-down menu option or button to format them, and doing it - it's quite straightforward.

Row and Column Sizing

Pick the line in between the row or column and drag it to resize the row or column. You may also select rows or columns (select the row number(s) to select a whole row or rows, and grab the column letter(s) to select a column or columns) and either pick "Format" and "Autofit" which will size the columns/rows to fit the data, or specify the height and width via subsequent menus.

Text Alignment

Text may be aligned center, right or left easily with these buttons from the menu:

Fonts may be selected and changed by selecting the cells to be changed, and then picking "Format" and "Cells" then "Font" from the pop-up menu. Font, text size, bold face, italic and underlined features can be quickly applied by using these buttons from the menu:

Cell borders, background colors, and text colors can be quickly modified using these buttons with drop-down menus available when you click on the arrows:

These functions are fairly intuitive and should be self explanatory once you start exploring them.

Summary

Excel is a powerful analysis tool for the engineer or architect, with capabilities which go far beyond simply keeping track of data. Calculations may be standardized, optimized, reiterated, and compared rapidly and with graphical feedback. Most basic mathematical, financial and logical functions used in everyday calculations can easily be set up in a spreadsheet, saving time and providing a benchmark for future reference.