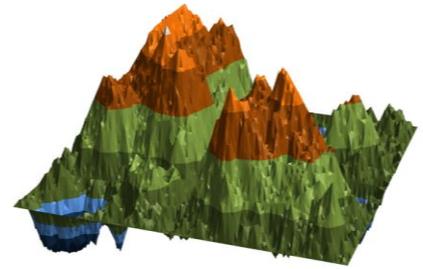
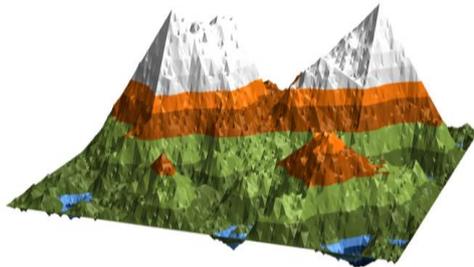
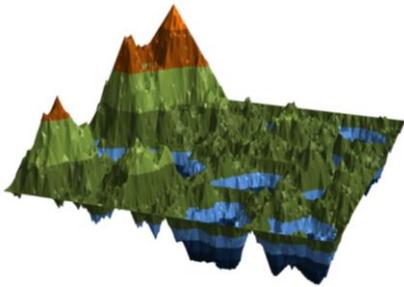
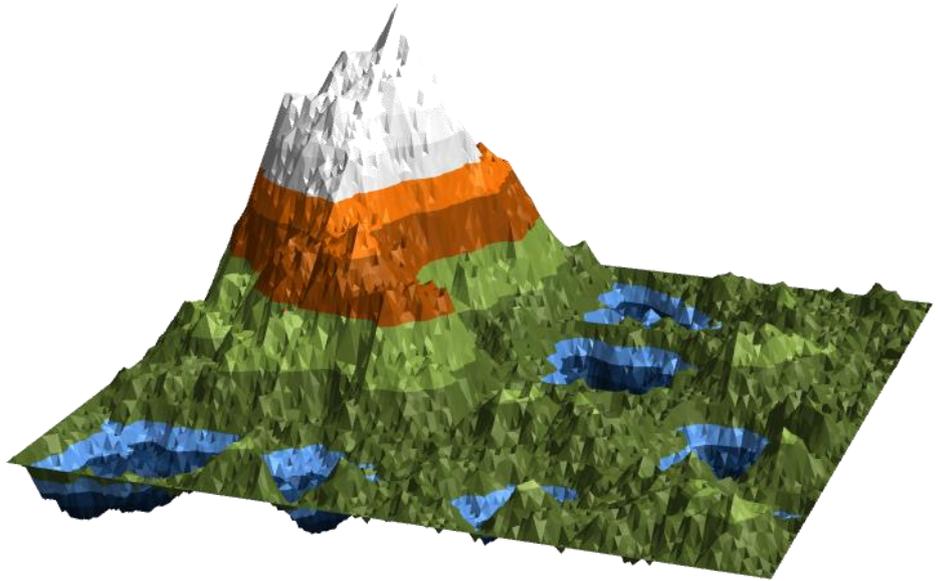


Creating Randomly Generated Terrain Using Excel

It is sometimes necessary to create realistic three-dimensional terrain for use in computer games, special effects in movies, computer simulations etc. Designing every part of the terrain by hand is an extremely complicated and time intensive task.

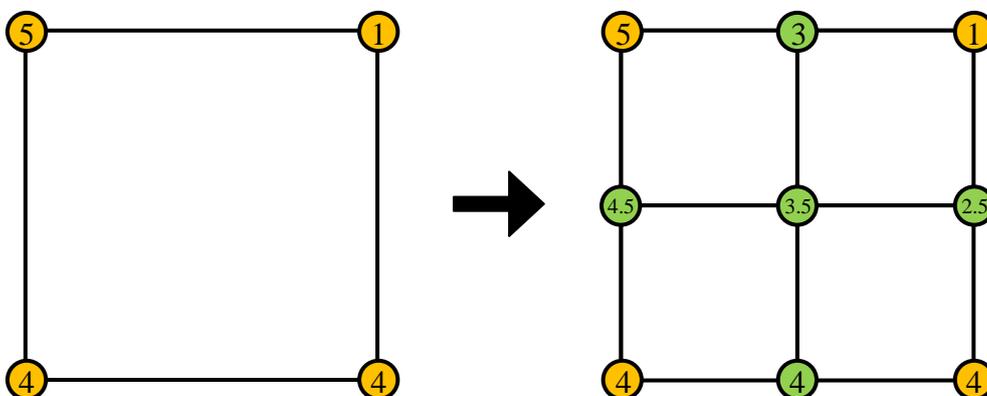
There are mathematical algorithms that we can use to create realistic terrain. The model on the right was created in Excel in less than one hour using only the AVERAGE function and the RANDBETWEEN function.

Every time the Excel worksheet is refreshed a new model is randomly created:

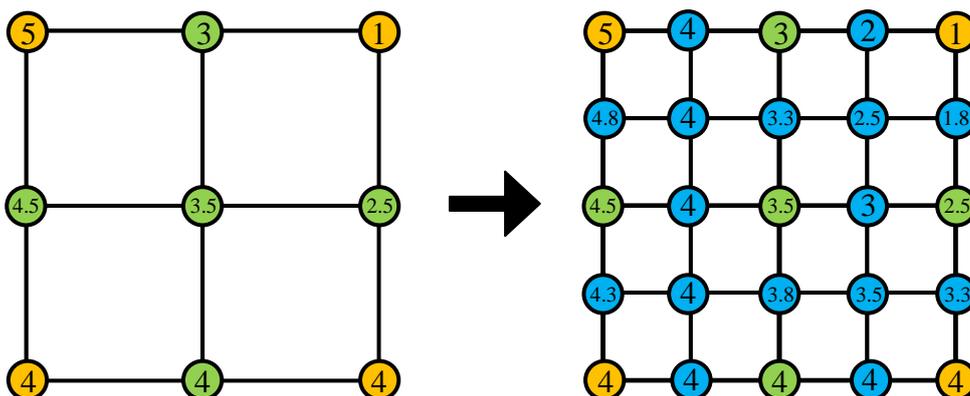


The models were created using the following algorithm:

Start with a rectangle or square. Assign a value to each vertex. This value represents the height of the vertex above the ground. Divide the rectangle into four similar rectangles. The number assigned to each of the four green vertices on the outside is equal to the average value of the orange two vertices on either side. The number assigned to the green vertex in the center is equal to the average value of the four surrounding green vertices, plus a random number. The diagram below demonstrates this (without the random number included).



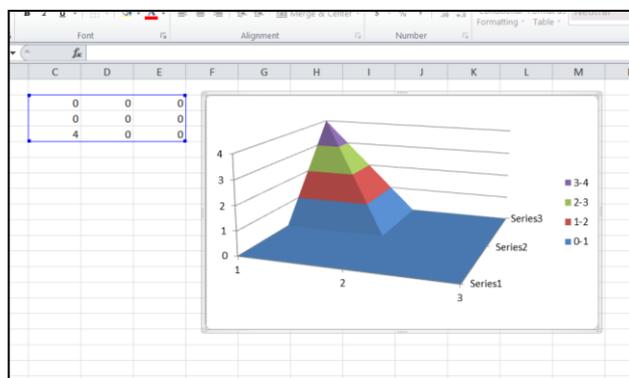
This process is performed repeatedly, each time creating smaller rectangles. The diagram below shows the next stage (without the random numbers included). All values are written to 1 decimal place (this is not a requirement).



Task 1

Enter nine zeros in three rows and three columns in Excel. Highlight them and create a 3D surface chart.

Change some of the zeros to different values, one at a time, to see the effect it has on the surface chart. Experiment until you have a good understanding of how Excel creates 3D surface charts.

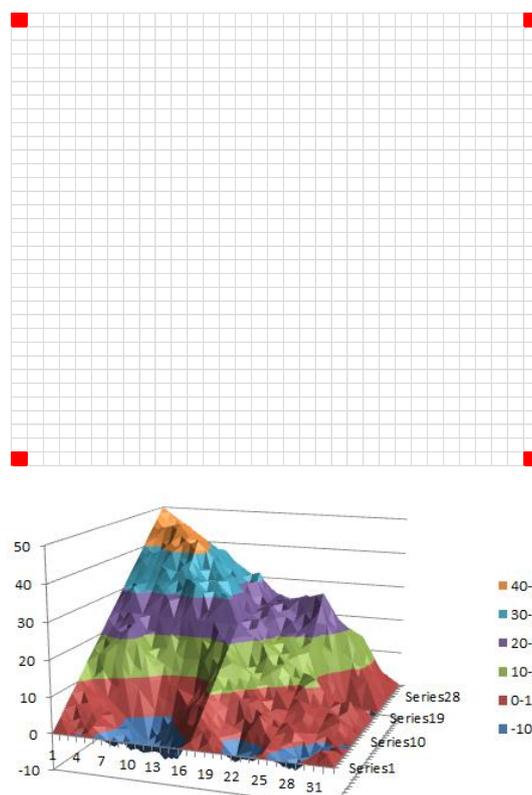


Task 2

Using the described algorithm create a terrain model in Excel. Begin using 33 rows and 33 columns. You should be able to control only the height of the four corners (the red cells in the image on the right).

Remember, the middle cell at each stage is equal to the average value of the four surrounding cells, plus a random number. At the n^{th} stage let this random number be between $-2^{-n}x$ and $2^{-n}x$, where the value of x is stored in a cell. To begin, let the value of x be equal to 100. You can experiment with other values later.

Tip: at each stage of the algorithm fill the cells you are working with in a different colour to those used in the previous stage.



Task 3

By copying and pasting relevant cells from the previous task increase the size of your model to 129 rows and 129 columns. You should only be able to control the red cells in your model.

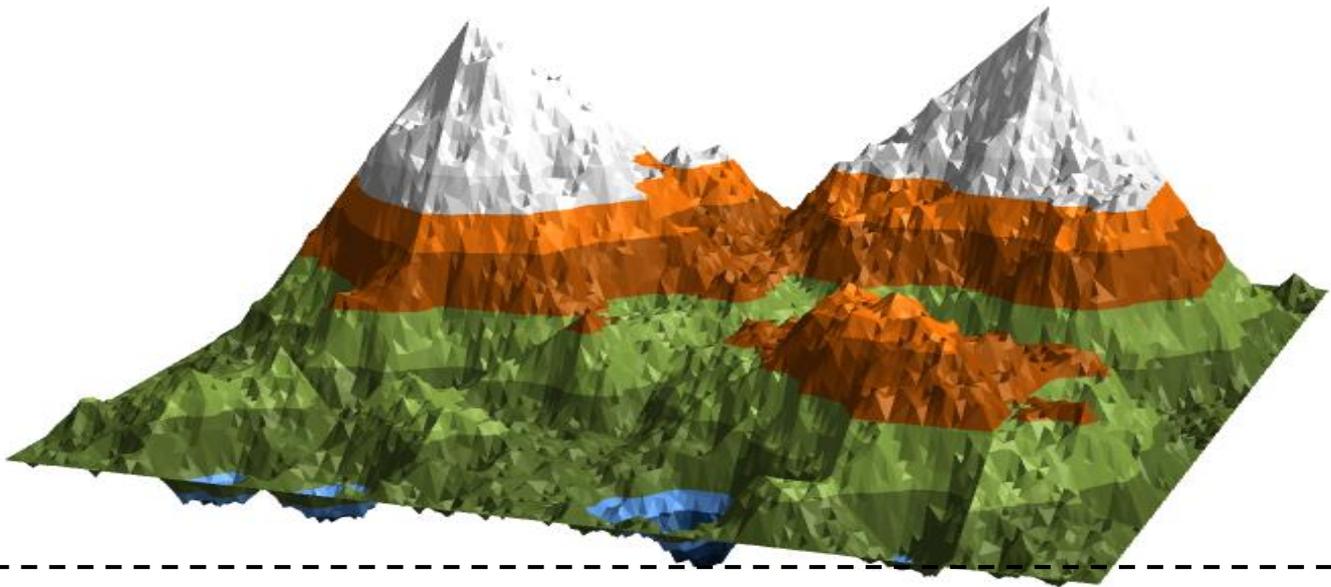
Tip: to make it easier to change any of these 25 red cells you should link them to five rows and columns of cells (see the image on the right).

Edit your surface chart so that it uses realistic colours.

Tip: to change the spacing of the colours right-click on the vertical axis, select Format Axis... and change the vertical major unit.

Experiment creating different models by changing the value of x and the values of some of the red cells.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2		0	0	0	0	0									
3		0	0	0	50	0				x	75				
4		0	100	50	0	0									
5		0	50	30	100	0									
6		0	0	0	0	0									
7															
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0.303	-0.71	-0.1	-0.7	-2.9	-2.3	-2.6	-0.3	0.4	-0.2	-2.2	0.48	-0.6	
10	0	-0.707	-1.41	-1.4	-1.5	-3.1	-4.7	-2.6	-0.5	-0.5	-0.5	0.24	0.95	1.57	
11	0	-0.061	-1.43	-4.2	-2.2	-5.1	-3.3	-3.4	-0.8	-1.8	-0	2.36	1.43	1.86	
12	0	-0.727	-1.45	-2.2	-2.9	-2.4	-2	-1.5	-1.1	-0.3	0.42	1.16	1.91	2.84	
13	0	-2.127	0.43	-2.3	-2.4	-4.4	-1.7	-3.9	-1.3	0.38	0.78	0.33	2.57	5.42	
14	0	1.16	2.32	0.17	-2	-1.7	-1.5	-1.5	-1.6	-0.2	1.13	2.18	3.23	6.69	
15	0	-1.896	0.89	0.34	-1.5	-0.9	-1.5	-4	-1.9	1.31	1.18	2.19	3.9	5.12	
16	0	-0.266	-0.53	-0.8	-1.1	-1.3	-1.6	-1.9	-2.1	-0.5	1.22	2.89	4.56	6.23	
17	0	2.717	2.12	0.18	0.93	-1.9	-0.1	-0.6	-0.5	-0.1	0.93	4.63	7.01	5.9	
18	0	2.387	4.77	3.85	2.92	2.15	1.38	1.3	1.22	0.93	0.65	5.05	9.45	8.26	
19	0	3.713	4.11	5.17	4.91	4.89	3.56	3.88	2.89	1.63	5.05	9.13	11.9	10.3	



Create a report of your work using Word (or similar) showing the results of task 3. Be sure to include:

- an introduction
- an explanation of the algorithm you used to create your models
- examples of terrain generated by your spreadsheet

All explanations should be in your own words.

Teacher Notes

The RANDBETWEEN function in Excel only accepts non-negative values, for example:

=RANDBETWEEN(0,10)

=RANDBETWEEN(12,20)

=RANDBETWEEN(34,87)

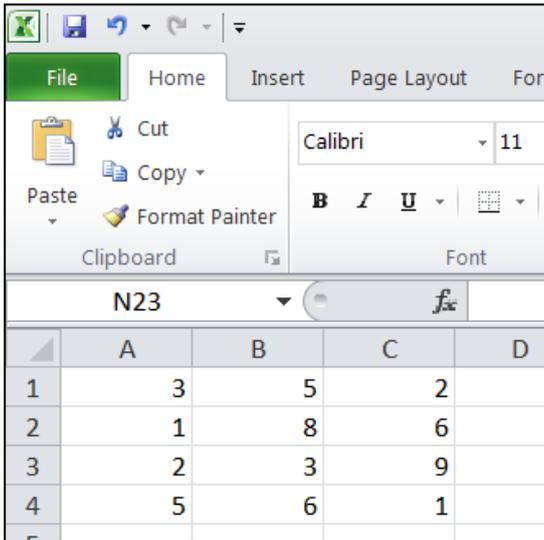
To generate a random number between, for example, -10 and 10 use:

=RANDBETWEEN(0,20)-10

Excel Tutorial

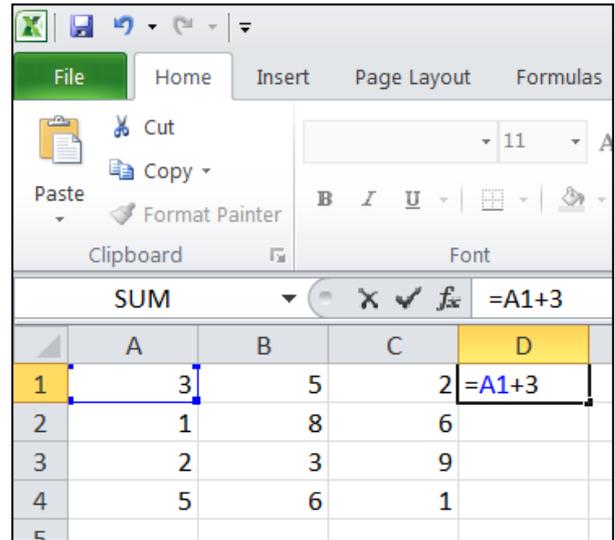
Relative References

Type the following values into cells A1 to C4:



	A	B	C	D
1	3	5	2	
2	1	8	6	
3	2	3	9	
4	5	6	1	

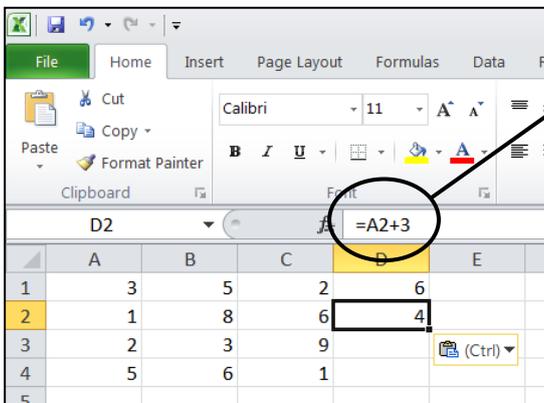
Type the following equation into cell D1:



	A	B	C	D
1	3	5	2	=A1+3
2	1	8	6	
3	2	3	9	
4	5	6	1	

Press *Enter* and the value displayed in cell D1 should be equal to 6.

Copy and paste cell D1 to cell D2:

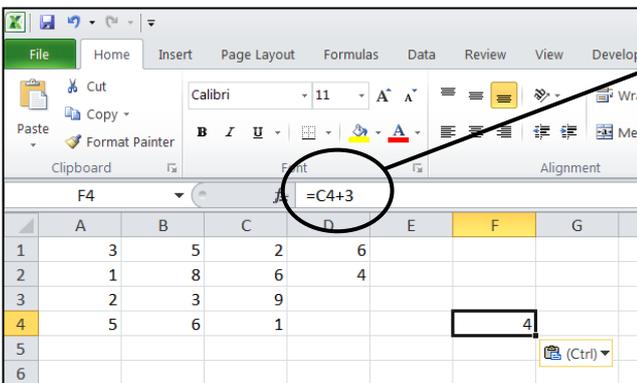


	A	B	C	D	E
1	3	5	2	6	
2	1	8	6	4	
3	2	3	9		
4	5	6	1		

Notice that the equation in cell D2 becomes A2+3.

This is because we pasted **one** row below cell D1, so the reference A1 becomes A2 (the row number increases by **one**).

Copy and paste cell D1 into cell F4:



	A	B	C	D	E	F	G
1	3	5	2	6			
2	1	8	6	4			
3	2	3	9				
4	5	6	1			4	
5							
6							

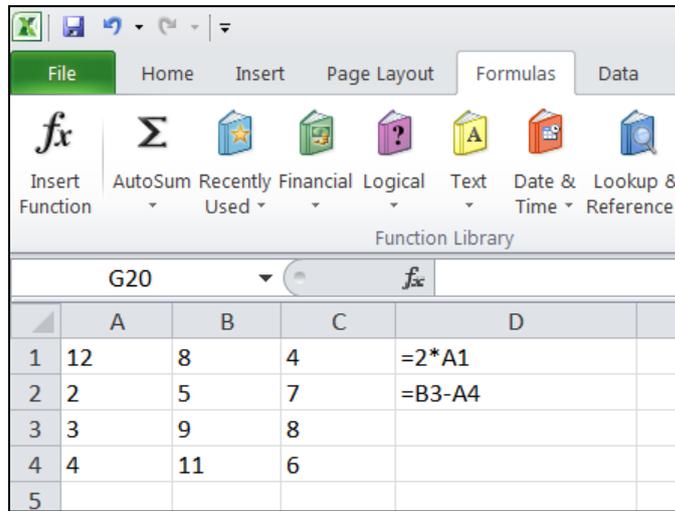
Notice that the equation in cell F4 becomes C4+3.

This is because we pasted **two** columns to the right and **three** rows below cell D1, so the reference A1 becomes C4 (the column letter increases by **two** and the row number increases by **three**).

These are examples of *relative references*.

Task 1

The following screenshot shows the contents of various cells (Note that you will not see the equations on your screen after you press *Enter*).



Complete the following table *without* using Excel. Then, check your answers using Excel.

For example, if we copy and paste cell D1 to cell E2, cell E2 will contain the equation $2*B2$ and will display the value of 10.

Copied From	Pasted To	Displayed Equation	Displayed Value
D1	E2	$2*B2$	10
D1	D4		
D1	E3		
D2	E1		
D2	F2		
D2	E3		

Absolute References

Type the following values in cells A1 to C4:
D3:

	A	B	C
1	3	8	9
2	2	6	4
3	1	7	2
4	5	3	8

Type the following equations into cells D1 to D3:

	A	B	C	D
1	3	8	9	=A\$1
2	2	6	4	=A1
3	1	7	2	=A\$1
4	5	3	8	
5				

Copy and paste cell D1 to E3:

	A	B	C	D	E	F
1	3	8	9	3		
2	2	6	4	3		
3	1	7	2	3	3	
4	5	3	8			
5						

Notice that even though we pasted to a new column and row, the cell reference doesn't change.

Placing a \$ sign in front of the column letter means the column letter will never change.

Placing a \$ sign in front of the row number means the row number will never change.

Copy and paste cell D2 to E4:

	A	B	C	D	E	F
1	3	8	9	3		
2	2	6	4	3		
3	1	7	2	3	3	
4	5	3	8		1	
5						
6						

Since there is a \$ sign in front of the column letter, the column letter will never change.

Cell E4 is **two** rows below cell D2, so the row number increases by **two**.

Copy and paste cell D3 into cell F4:

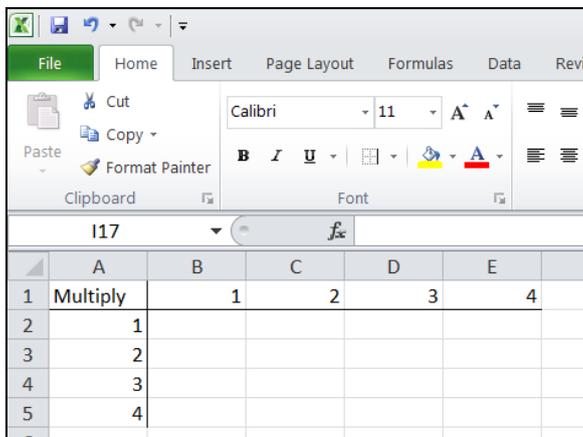
	A	B	C	D	E	F	G
1	3	8	9	3			
2	2	6	4	3			
3	1	7	2	3	3		
4	5	3	8		1	9	
5							
6							

Since there is a \$ sign in front of the row number, the row number will never change.

Cell F4 is **two** columns to the right of cell D3, so the column letter increases by **two**.

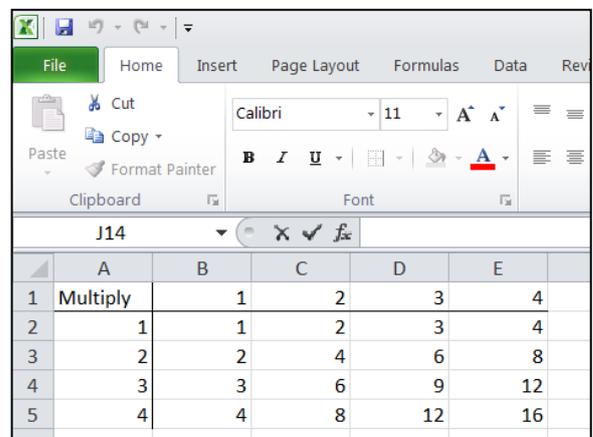
Task 2

Enter one equation into cell B2, so that when it is copied and pasted into all of the other cells it correctly fills in the multiplication table:



The screenshot shows the Excel interface with the Home tab selected. The formula bar displays $=A2*B2$. The worksheet contains a multiplication table with the following data:

	A	B	C	D	E
1	Multiply	1	2	3	4
2		1			
3		2			
4		3			
5		4			



The screenshot shows the Excel interface with the Home tab selected. The formula bar displays $=A2*B2$. The worksheet contains a completed multiplication table with the following data:

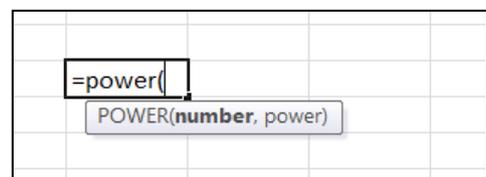
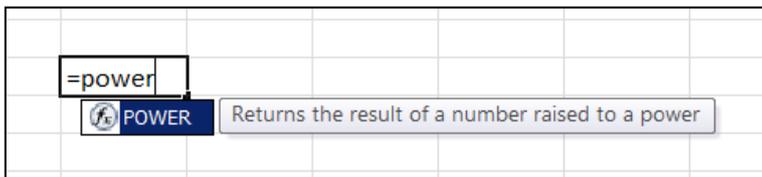
	A	B	C	D	E
1	Multiply	1	2	3	4
2		1	2	3	4
3		2	4	6	8
4		3	6	9	12
5		4	8	12	16

Mathematical Functions

Excel contains many mathematical functions. For example:

$\sin()$, $\cos()$, $\tan()$, $\text{asin}()$, $\text{acos}()$, $\text{atan}()$, $\text{sqrt}()$, $\text{power}()$, $\text{int}()$, $\text{randbetween}()$, $\text{sum}()$, $\text{average}()$, $\text{countif}()$

As you type the function into Excel, you will often be given a description of the function and what kind of values it accepts:



Examples

- Typing $=\text{power}(3,4)$ will display the value of 81
- Type $=\text{sqrt}(9)$ will display the value of 3
- Typing $=\text{sum}(A1:A6)$ will calculate the sum of the contents of cells A1 to A6

Task 3

Use Excel to determine the following:

- a) the square root of 20
- b) the mean value of 20, 18, 23, 11, 25 and 19
- c) a randomly generated number between 5 and 13
- d) the inverse sine of 1
- e) the sum of all positive integers less than 10