

(e) Absolute and Relative Referencing

We have seen that a cell is identified by its column letter and row number. This combination is used to reference cells when creating formulae.

This simple explanation of how a cell is referenced hides an important fact. A cell reference can be either relative or absolute.

A relative cell reference refers to the position of the cell relative to where the cell containing the formula has been placed. This is best illustrated using the Row Column way of identifying cells. Using this method a relative reference (indicated by the square brackets) R[-1]C[1] would refer to a cell one row above and one column to the right of the cell containing the reference, while RC[-1] would refer to the cell in the same row but one column to the left of the current cell. The best way to illustrate this is with a simple example.

The spreadsheet below (Figure 14) produces the four times table. Columns 1 to 4 contain data or text. Column 5 contains a formula which is displayed in Row Column format. (Notice that,

	1	2	3	4	5	6	7
1	1	x	4	=	4		
2	2	x	4	=	8		
3	3	x	4	=	12		
4	4	x	4	=	16		
5	5	x	4	=	20		
6	6	x	4	=	24		
7	7	x	4	=	28		
8	8	x	4	=	32		
9	9	x	4	=	36		
10	10	x	4	=	40		

	1	2	3	4	5
1	1	x	4	=	=RC[-4]*RC[-2]
2	2	x	4	=	=RC[-4]*RC[-2]
3	3	x	4	=	=RC[-4]*RC[-2]
4	4	x	4	=	=RC[-4]*RC[-2]
5	5	x	4	=	=RC[-4]*RC[-2]
6	6	x	4	=	=RC[-4]*RC[-2]
7	7	x	4	=	=RC[-4]*RC[-2]
8	8	x	4	=	=RC[-4]*RC[-2]
9	9	x	4	=	=RC[-4]*RC[-2]
10	10	x	4	=	=RC[-4]*RC[-2]

since row column formatting has been turned on, the column letters have been replaced by numbers).

The formula in R1C5 (or E1 as it would be known in the more usual way of naming cells) is:

$$=RC[-4] * RC[-2]$$

The 'R' without any number means the current row. This is a relative reference and the formula is saying multiply the contents of the cell on the

current row but four columns to the left by the contents of the cell on the current row but two columns to the left.

Now the importance of using this relative reference is that, by using it, the same formula can be used all the way down column 5. This means that the formula need only be entered once and can be copied (replicated) down the column.

The right hand screenshot in Figure 14 shows the spreadsheet in formula view. Each cell in column 5 contains the same formula and this is possible only because relative addressing has been used.

Now let's look at the same spreadsheet using the more common way of referring to cells. Row Column formatting has been turned off and we see that the columns are identified by letters.

	A	B	C	D	E	F
1	1	x	4	=	4	
2	2	x	4	=	8	
3	3	x	4	=	12	
4	4	x	4	=	16	
5	5	x	4	=	20	
6	6	x	4	=	24	
7	7	x	4	=	28	
8	8	x	4	=	32	
9	9	x	4	=	36	
10	10	x	4	=	40	

	A	B	C	D	E
1	1	x	4	=	=A1*C1
2	2	x	4	=	=A2*C2
3	3	x	4	=	=A3*C3
4	4	x	4	=	=A4*C4
5	5	x	4	=	=A5*C5
6	6	x	4	=	=A6*C6
7	7	x	4	=	=A7*C7
8	8	x	4	=	=A8*C8
9	9	x	4	=	=A9*C9
10	10	x	4	=	=A10*C10

The first formula in column E is:

$$= A1 * C1$$

Despite appearance, this is a relative reference. In other words, it is the position of the cells relative to E1 that the spreadsheet works on, rather than their actual names. You will see that this is the case if you set up this spreadsheet and enter the formula in E1. If you then replicate (copy) the formula down the column you see that it changes so that the same two cells relative to the current position

Fig 15: Four Times Table Spreadsheet without Row Column Formatting

are multiplied together.

This type of situation occurs so often that a special way of copying cells that contain formulae has been developed. This allows the user to enter the formula once and to 'copy' it along a row

or column or even to paste it into another cell elsewhere on the sheet. Column and row references in the formula are automatically changed to reflect the position of the cell relative to the original. This can only happen if relative cell references are used and, in Excel, relative cell referencing is used by default simply because it is needed so often.

In some situations the user will not want the cell reference to change. An example is shown below for a spreadsheet that models the cost to a manufacturer of producing a certain number of computers.

Here cell C3 is used to calculate the cost of the CD drives. The cost of a CD drive (stored in cell B3) is multiplied by the number of computers produced, which is stored in cell D1.

The formula is replicated from cell C3 into the three cells below. You can see that the B3 part of the formula changes to B4, B5 and B6 as a relative cell reference has been used so that the original formula adjusts to its new row as it is copied down.

	A	B	C	D
1	Price	450	Computers Produced	20
2	Components	Unit Cost	Cost of components	
3	CD	60	=B3*\$D\$1	
4	VDU	100	=B4*\$D\$1	
5	Keyboard and Mouse	15	=B5*\$D\$1	
6	Base Unit	250	=B6*\$D\$1	
7		Total	=SUM(C3:C6)	
8	Costs		Revenue	
9	Components	=C7	Sales	=B1*D1
10	Wages	520		
11	Other Costs	120		
12	Total Costs	=SUM(B9:B11)	Total Revenue	=SUM(D9:D11)
13				
14			Profit	=D12-B12
15				

Fig 16: Costing Spreadsheet

However the user does not want D1 to become D2, D3 and D4 as the formula replicates, since this part of the formula refers to the number of computers produced and this is in cell D1. The \$ symbol indicates that this is an absolute reference. An absolute cell reference is one that will not change when a formula is replicated. \$D\$1 indicates that absolute replication should be applied to this part of the formula.

In some situations the user may want to specify that only the column or the row should be absolute. In this case only one \$ symbol would be used, placed in front of either the row or the column part of the cell reference as required.

(f) Simulations

Simulations are a special kind of model. They usually involve a range of outcomes that vary over time. Examples include simulating the queues at supermarket checkouts, traffic flow at road junctions and so on. This type of simulation allows the behaviour of the system to be speeded up and observed over minutes rather than over hours or days

Sometimes simulations change over space as well as or instead of time. An example of this would be a simulation of a completed building project that allowed the user to 'walk' through the completed building.

At the extreme end, special hardware and software is needed to produce a simulation, as is the case with a flight simulator used to train airline pilots which is an example of a real-time