

## Array Formulas in Excel 2016

When using array formulas in Excel, a special key combination is essential in order to obtain the desired results. Array formulas are different from single value formulas in that they output an array or a set of multiple values (up to 6500!). Array formulas are used to help save time spent on entering a set of results instead of a single value.

In order for Excel to recognize that an array is being used, the key combination **CTRL+SHIFT+ENTER** must be used instead of just the **ENTER** key when calculating the results. Pressing **ENTER** alone will produce a single value instead of multiple values. This is because Excel uses only the first item in the array when **ENTER** is pressed alone and thus a single result is produced.

This key combination is used when dealing with any kind of array where multiple values are needed, i.e., matrix array multiplication, statistical data, financial values or when using the functions **COLUMN**, **COLUMNS**, **GROWTH**, **HLOOKUP**, **INDEX**(array form), **LINEST**, **LOGEST**, **LOOKUP**(array form), **MATCH**, **MDETERM**, **MINVERSE**, **MMULT**, **ROW**, **ROWS**, **SUMPRODUCT**, **TRANSPOSE**, **TREND**, and **VLOOKUP** along with others.

The following is an example using the **MMULT** and **MINVERSE** functions with the **CTRL+SHIFT+ENTER** key combination.

### 1. Open Excel

After the login is complete, the **Start** button will appear at the bottom left of the screen. Type **Excel** in the search bar and open **Excel 2016**.

### 2. Using **MINVERSE** and **MMULT**

To invert a matrix, a function called **MINVERSE** is used. First, create the matrix below:

$$\text{Matrix A} = \begin{bmatrix} 3 & 1 & -1 \\ 1 & 2 & 3 \\ -5 & -8 & 12 \end{bmatrix}$$

The matrix must have an equal number of rows and columns in order to be invertible. Highlight an area blank cells of corresponding size in which the resulting matrix should be placed.

	A	B	C	D	E	F
1						
2		Matrix A=				
3		3	1	-1		
4		1	2	3		
5		-5	-8	12		
6						
7		A inverse =				
8						
9						
10						
11						
12						

Then click on the **Formulas** Tab, then select **Math & Trig** from the Function Library category, then scroll through the Function Name list and select **MINVERSE**, then **OK**. In the formula line, you will now see:

=MINVERSE()

A Formula Palette will appear below. Click the button on the right side formula bar, and then select the matrix array with the mouse. Click back on the right side of the formula bar to return to the formula palette. If the correct cells are selected the formula line should now resemble:

		MINVERSE		: X ✓ f_x		=MINVERSE(B3:D5)	
	A	B	C	D	E	F	
1							
2		Matrix A=					
3		3	1	-1			
4		1	2	3			
5		-5	-8	12			
6							
7		A inverse =					
8		RSE(B3:D5)					
9							
10							
11							

When you are finished, select the formula line at the top and press **Ctrl-Shift-Enter** (at the same time!!!) **Do Not Press Enter Alone!!** Pressing enter alone will only produce one value instead of a matrix.

To multiply two matrices together, the function called **MMULT** is used. First, create the two matrices below:

$$\text{Matrix A} = \begin{bmatrix} 3 & 1 & -1 \\ 1 & 2 & 3 \\ -5 & -8 & 12 \end{bmatrix} \quad \text{Matrix B} = \begin{bmatrix} 10 \\ 12 \\ 22 \end{bmatrix}$$

In order to multiply two matrices, the number of columns in the first matrix must be equal to the number of rows in the second matrix. Highlight an area of blank cells with the proper dimension where the resulting matrix should be placed which will have the same number of rows as the first matrix and the same number of columns as the second matrix. Then click on **Insert Function** ( $f_x$ ) on the Formulas menu bar. In **Step 1 of 2** of the Function Wizard select **Math & Trig** from **Select a Category**, then scroll the **Select a Function** list and select **MMULT**, then **OK**. In the formula line, you will now see:

=MMULT()

Along with a formula palette. Click on the button on the right side of the Array1 formula bar and then select the first matrix array with the mouse. Click back on the button on the formula bar to return to the formula palette. Now, select the button on the right side of the Array2 formula bar, and select the corresponding matrix. Return to the formula palette. The formula line should now resemble:

	A	B	C	D	E	F
1						
2		Matrix A=				Matrix B=
3		3	1	-1		10
4		1	2	3		12
5		-5	-8	12		22
6						
7		A inverse =				
8		0.4173913	-0.0347826	0.04347826		
9		-0.2347826	0.26956522	-0.0869565		
10		0.0173913	0.16521739	0.04347826		
11						
12		A <sup>(-1)</sup> *B =				
13			10,F3:F5)			
14						
15						
16						

When you are finished with that, select the formula line at the top and press **Ctrl-Shift-Enter** (at the same time!!!) **Do Not Press Enter Alone!!** Pressing enter alone will only produce one value instead of a matrix.

**Example:**

Solve the set of linear equations:

$$\begin{aligned} 3x+y-z &= 10 \\ x+5y+3z &= 12 \\ -5x-8y+12z &= 22 \end{aligned}$$

To solve using matrices, use the equation  $Ax=b$  where matrix A is the coefficient matrix, x is the variable matrix and b is the matrix of given solutions. Therefore,  $x=A^{-1}*b$ .

Matrix A=				Matrix b=	
3	1	-1		10	
1	5	3		12	
-5	-8	12		22	
A <sup>(-1)</sup> =					
0.404	-0.019	0.038			
-0.130	0.149	-0.048			
0.082	0.091	0.067			
A <sup>(-1)</sup> *b=					
4.654					
-0.567					
3.394					

The  $A^{(-1)}*b$  matrix is the matrix with values of x, y, and z. This gives the answers  $x=4.71$ ,  $y=-1.026$  and  $z=3.113$ .