
Notes on Excel Calculations



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EXCEL REVIEW
2007

This handout is meant to serve as a quick review of some of the principal features of Excel formulas and calculations. It's not meant to cover Excel's formulas or calculations in great depth.

This guide may jog your memory about a feature or two you might have used and then forgotten or introduce you to something new in Excel that you'd like to explore further.

If you're not already familiar with a feature described here and you think it might be useful to you, I hope you'll consult Excel's online help or a good reference guide for a complete description.

Examples and illustrations are drawn from Excel 2000. They are substantially the same in the more recent versions of Excel.

*Paula Ecklund
Spring 2007*

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I. Formula Basics

✓ The Building Blocks: Values, Cell References, & Operators

The building blocks of Excel formulas are values, cell references, and operators.

A **value** can take the form of a number (20, 100, .015), text (“The Fuqua School of Business”, “Duke basketball”), or a date (4/1/01, April 1, 2001).

A **cell reference** identifies a single cell or a range of cells on a worksheet and tells Excel where to look for the values or data you want to use in a formula. With references, you can use data contained in different parts of a worksheet in a single formula or use the value from one cell in several formulas. You can also refer to cells on other sheets in the same workbook, to other workbooks, and to data in other programs. References to cells in other workbooks are called external references. References to data in other programs are called remote references.

Excel has two cell reference styles: The A1 style and the R1C1 reference style. By default, Excel uses the A1 reference style. This style refers to columns with letters (A through IV, for a total of 256 columns) and to rows with numbers (1 through 65,536). These letters and numbers are called row and column headings. To refer to a cell, enter the column letter followed by the row number. For example, D50 refers to the cell at the intersection of column D and row 50. To refer to a range of cells, enter the reference for the cell in the upper-left corner of the range, a colon (:), and then the reference to the cell in the lower-right corner of the range.

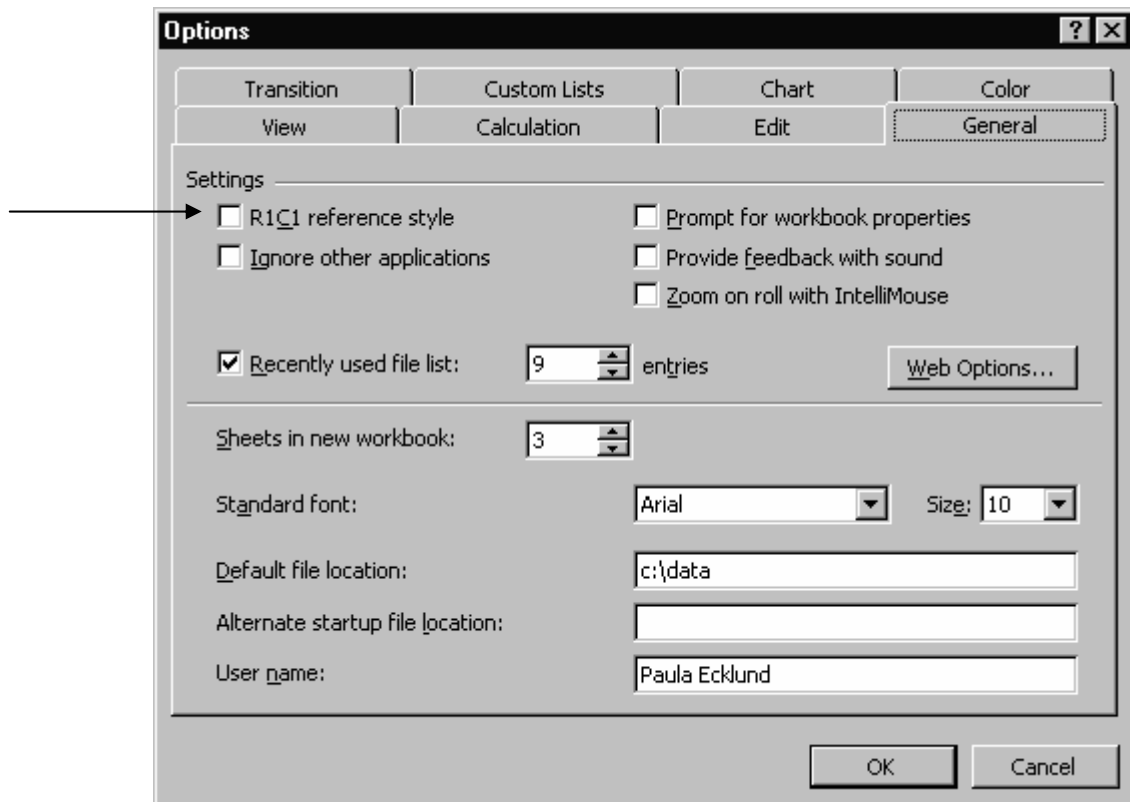
Examples of A1-style references:

To refer to	Use
The range of cells in Column A and rows 10-20	A10:A20
The range of cells in Columns A-E and rows 1-20	A1:E20
All the cells in row 5	5:5
All the cells in rows 5 through 10	5:10
All the cells in Column A	A:A
All the cells in Columns B through H	B:H

To experiment with any reference types that may be unfamiliar to you, click the F5 key to open Excel's "Go To" dialog box and enter a reference in the "Reference" box to see the cell/range selection in your spreadsheet.



With the R1C1 reference style, both the rows and the columns on a worksheet are numbered. The R1C1 style is particularly useful for computing row and column positions in macros. In the R1C1 style, Excel indicates the location of a cell with an "R" followed by a row number and a "C" followed by a column number. Toggle on or off the R1C1 reference style by choosing *Tools, Options* and selecting the "General" tab.



Excel's formula **operators** specify the type of calculation to perform on the elements of a formula. Excel has four different types of calculation operators: arithmetic, comparison, text, and reference

Arithmetic operators

The arithmetic operators perform basic arithmetic operations. Addition (+), multiplication (*), exponentiation (^), etc.

Comparison operators

The comparison operators compare two values with a result of either TRUE or FALSE. For example, greater than (>), less than or equal to (<=), not equal to (<>), etc.

Text operator

The single text operator (the ampersand, &) allows you to join one or more text strings together. For example "Duke"&" University" results in "Duke University".

Reference operators

The two reference operators (the colon range operator and the comma union operator) allow you to combine ranges of cells in calculations. For example, B5:B15 uses the colon range operator to refer to all the cells between and including B5 and B15. The formula =SUM(B5:D5,B6:D6,B7) uses the comma union operator to add the values in the seven specified cells.

✓ Excel's Order of Calculation

If you use more than one operator in a calculation, Excel evaluates them in the order shown below.

If the calculation contains operators that have the same precedence (such as division and multiplication), Excel evaluates left to right.

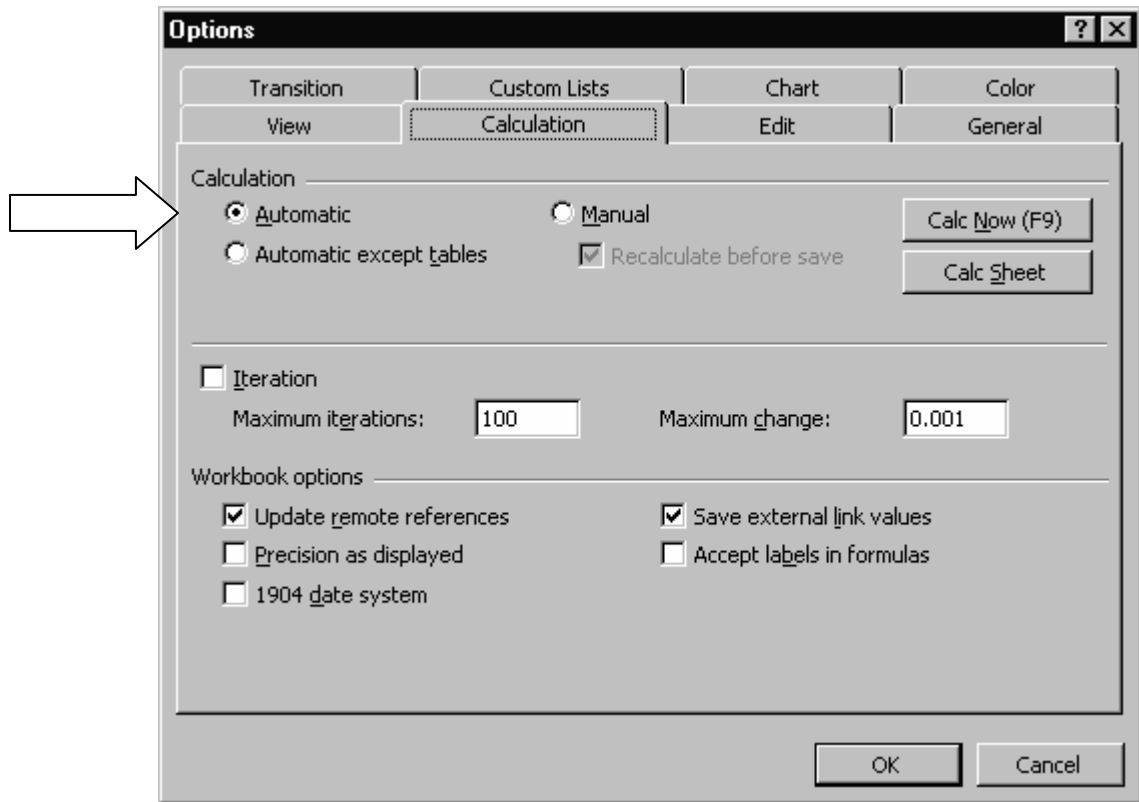
Change the order of calculation by enclosing in parentheses the part of the formula you want calculated first.

Operator	Description
:	Reference operator
(single space)	
,	
-	Negation (as in -12)
%	Percent
^	Exponentiation
* and /	Multiplication and Division
+ and -	Addition and Subtraction
&	Concatenation
= < > <= >= <>	Comparison

✓ Controlling calculation in workbooks

Excel's calculation is the process of computing formulas and then displaying the results as values in the cells that contain the formulas. By default, Excel automatically executes the formulas in all open workbooks, and when a workbook is opened or saved. Excel recalculates any cells that are dependent on other cells whose values have changed. This default calculation method is termed **automatic** calculation.

However, you can control when calculation occurs. Choose *Tools, Options* and then choose the "Calculation" tab to see Excel's calculation options.



If you select an option other than **Automatic**, press F9 (or the "Calc Now (F9) key) to make Excel perform calculations in all worksheets in all open workbooks. To calculate only the *active* worksheet, press SHIFT+F9 (or the "Calc Sheet" button).

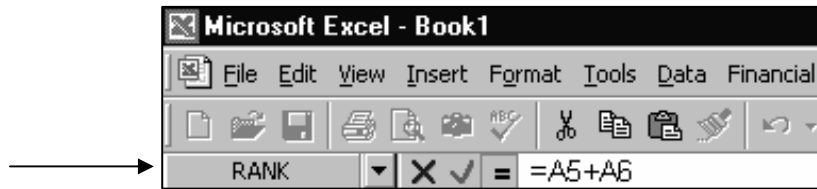
Excel calculates *stored*, not *displayed*, values. The displayed (and printed) value depends on how you choose to format and display the stored value. For example, a cell that displays a date as **6/22/96** also contains a serial number that is the stored value for the date in the cell. You can change the display of the date to another format (for example, to **22-Jun-96**), but changing the display of a value on a worksheet doesn't change the stored value.

While Excel is performing calculations, you can choose commands or perform actions such as entering numbers or formulas. Excel temporarily interrupts its calculation to carry out the other commands or actions and then resumes calculation. The calculation process may take more time if the workbook contains a large number of formulas, if the worksheets contain data tables, or if the worksheets contain functions that automatically recalculate every time the workbook is recalculated. Also, the calculation process may take more time if the worksheets contain links to other worksheets or workbooks.

✓ Entering & Editing Formulas

There are a number of different ways to enter and edit a formula in Excel. All Excel formulas begin with an equals sign.

Click in the cell where you want the formula and begin typing. Or, click in the cell where you want the formula and click the equals button on Excel's formula bar. Hit enter (or click the green check mark on the formula bar) when you've completed entering the formula.



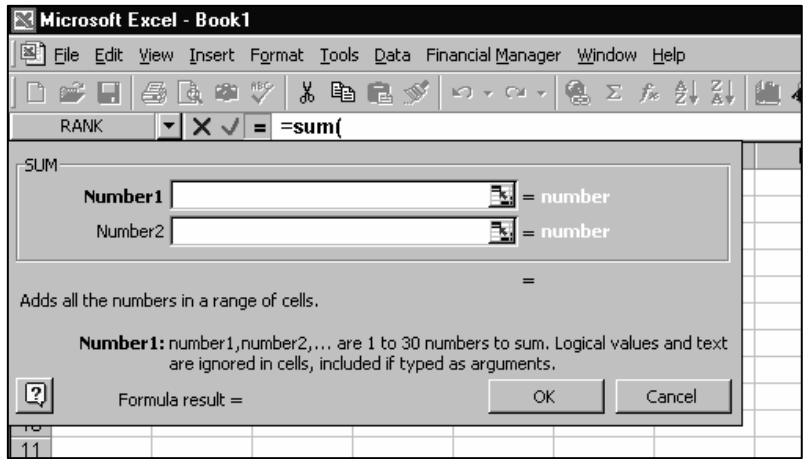
The formula bar displays at the top of the Excel workspace below Excel's menu bars and any open toolbars. The formula bar includes a "Name Box"/function list at left, an X mark to cancel a formula, a check mark to enter a formula, and an equals sign to begin a formula. The formula itself displays at right in the formula bar. The result of the formula you typed appears in the spreadsheet cell.

You'll almost always use cell references in the formulas you build. You need not enter cell references into a formula by typing them, however. Instead, once your formula is started (once you've typed an equals sign), you can click a cell whose reference you want included in the formula. Using this technique can spare you entering mistaken references.

For example, to use this technique to enter the formula = SUM(B1,C25)*F3, follow this sequence:

Type	=SUM(
Click	Cell B1
Type	,
Click	Cell C25
Type)*
Click	Cell F3
Click	the enter key

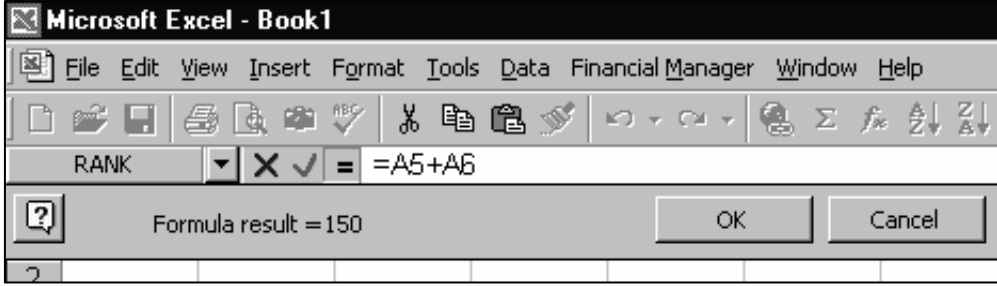
Excel makes available a feature called the **Formula Palette**. The palette displays when you click the equals button on the formula bar to create (or edit) a formula. The palette has two display modes: One, if you're entering a formula that includes one of Excel's built-in functions and the another if you're entering a formula *without* a built-in function.



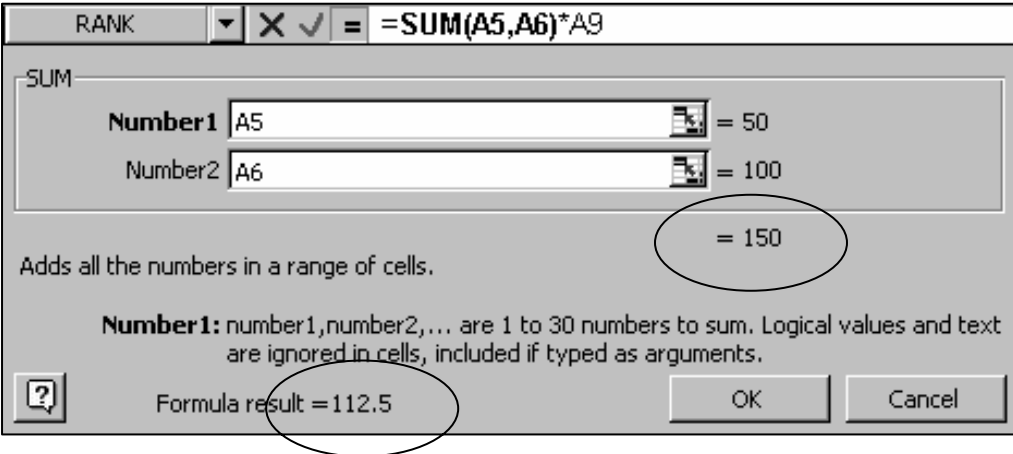
The formula palette that displays if your formula includes a built-in function.

In the palette, Excel displays information about how to complete the function.

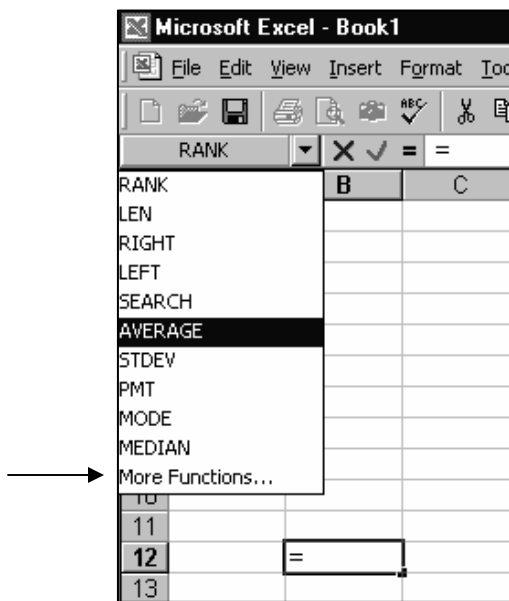
The formula palette that displays when no built-in functions are used in the formula.



Both palette views show what the result of the formula will be. If you're including a function, the palette shows the result of the function as well as the result of the formula.

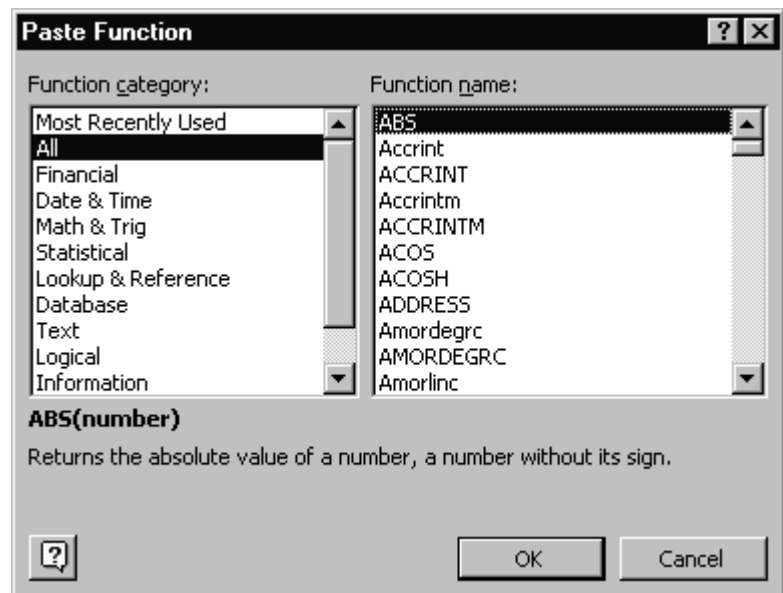


The sum function result is 150 but the formula result is 112.5. Both are displayed in the formula palette. The values used in the function also display.



If you type an equals sign into a cell and then click the drop-down arrow at the left-hand side of the formula bar, a list of built-in Excel functions displays. If you choose a function from the list, the formula palette with that function displays.

Selecting the *More Functions...* option at the bottom of the list opens Excel's "Paste Function" dialog, that gives you access to all of Excel's built-in functions.

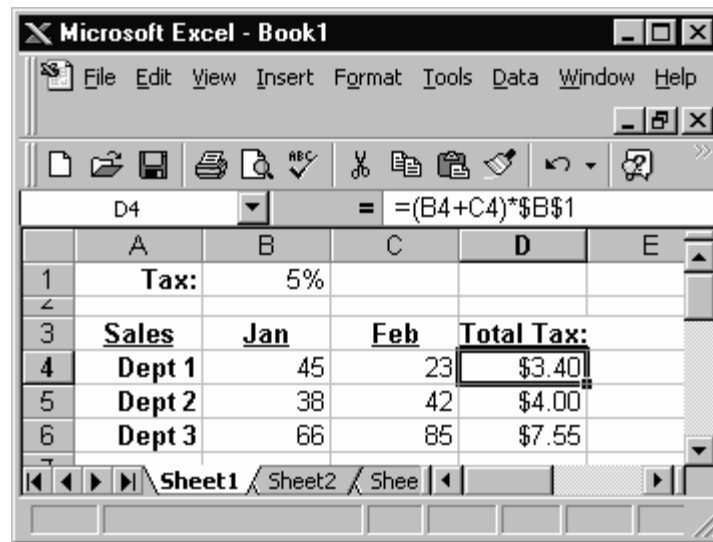


✓ Formula-Building Recommendations

Formulas express relationships between values, both known and variable. Avoid using numbers (actual data) in Excel formulas. Instead use cell references that point to cells that hold the data. By keeping each data item in a unique location in the worksheet you can much more easily change an item if necessary and have the change be reflected wherever the item is used throughout the worksheet.

In the illustration below a tax rate value is stored in Cell B1. The calculations in Column D all use that tax rate value. Instead of including the actual value of 5% in the formulas, a reference to that cell is made. The formulas in Column D are:

$=(B4+C4)*\$B\1
 $=(B5+C5)*\$B\1
 $=(B6+C6)*\$B\1



Should the tax rate change from 5% to 6% *only* the value in the tax rate cell, B1, must change. The formulas that use the tax rate refer to the cell, so they need not be changed.

By contrast, if the formulas you build use *actual* values, you'll spend much more time finding and editing values should they change. For example:

Use This	Instead of This
$=(B4+C4)*\\$B\\1	$=(45+23)*5\%$
$=(B5+C5)*\\$B\\1	$=(28+42)*5\%$
$=(B6+C6)*\\$B\\1	$=(66+85)*5\%$

✓ Calculating With Date & Time Values

Excel stores dates as sequential numbers known as serial values. Excel stores times as decimal fractions because time is considered a portion of a day. Because Excel treats dates and times as values they can be added, subtracted, and included in other calculations.

For example, to determine the difference between two dates, subtract one date from the other.

View a date as a serial value and a time as a decimal fraction by changing the format of the cell that contains the date or time to **General** (number) format. For example:

<u>Date</u>	<u>Number</u>
4/10/01	36991
3:15	0.1354

For a date calculation, either refer in the formula to cells that contain dates, or -- to include actual dates in the formula -- surround them with double quotes. For example, this formula:

= "4/10/01" - "3/10/01"

yields the value **31**.

Excel supports two date systems: the 1900 and 1904 date systems. The default date system for Excel is 1900. If you have a need to the 1904 date system, choose *Tools, Options*, select the "Calculation" tab and toggle on the 1904 date system check box. The table below shows the first date and the last date for each date system and the serial value of each.

1900	January 1, 1900 (serial value 1)	December 31, 9999 (serial value 2958465)
1904	January 2, 1904 (serial value 1)	December 31, 9999 (serial value 2957003)

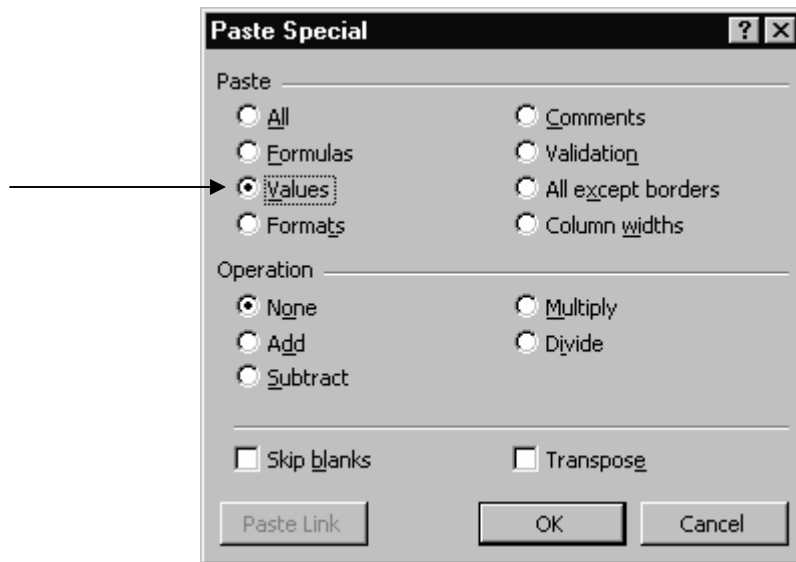
Use the DATE function to manipulate a part of a date within a formula. Use the TIME function to manipulate a part of a time -- such as the hour or minute -- within a formula. See the "Date & Time" category of Excel's built-in functions for more options.

By default, dates entered in a workbook are formatted to display two-digit years. Use the Windows Control Panel to change the default date format if you want to display four-digit years instead of two-digit years.

✓ Replacing a Formula with a Value

You may occasionally need to replace a formula in a spreadsheet with that formula's calculated value. Excel permits you to replace all or part of a formula with its value.

To replace the entire formula with its value, choose the cell or range that contains formulas you want to replace. Copy them to the Windows Clipboard with *Edit, Copy*. Leave the same range highlighted and issue the *Edit, Paste Special* command to open the "Paste Special" dialog.

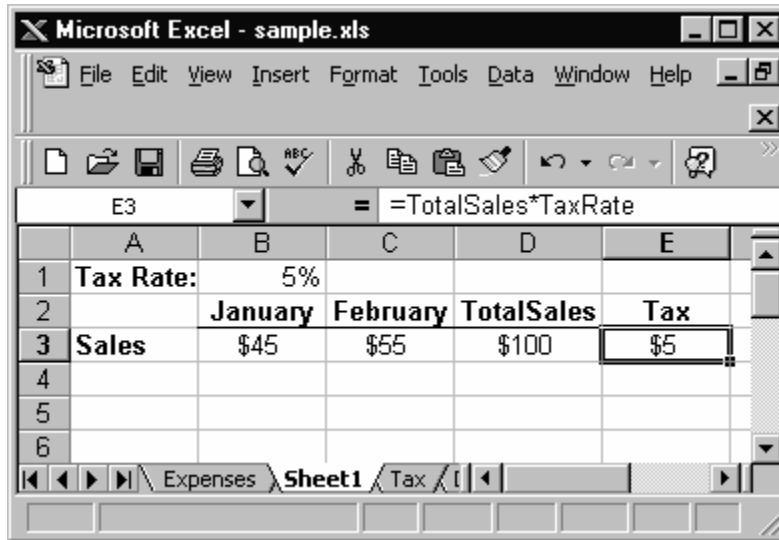


Choose the *Values* option and click *OK*. Excel replaces the formulas with their values.

To replace just *part* of a formula with its value, select the cell that contains the formula. In the formula bar, highlight the part of the formula you want to replace with its calculated value. (When you select the part of the formula you want to replace, make sure to include the entire thing. For example, if you select a function, select the entire function name, the opening parenthesis, the arguments, and the closing parenthesis.) Press the F9 key to force calculation of the selected part of the formula. Then hit the Enter key. Excel replaces the selected part of the formula with its calculated value.

✓ Naming Cells & Ranges Used in Formulas

Excel will use names in place of cell references in formulas. Naming key cells can make your worksheet formulas easier to read. In the example below, the formula bar displays the formula in Cell E3 as `=TotalSales*TaxRate`. Without cell names, the formula would display as the less comprehensible `=D3*B1`.



If you assign names to cells *after* having used those cells in calculations, Excel doesn't automatically replace cell references in the calculations with the new cell names. However, you can over-ride this default and have new names used post-formula-creation with the command *Insert, Name, Apply*.

Quickly name a cell or range by selecting it and entering the name in the "Name Box" at the left of the formula bar. The Name Box displays the current cell or range reference or the current cell or range name, if one is assigned.

Name a cell or range to be able to go to it quickly using the F5 "Go To" key. Hitting F5 opens the *Go To* dialog box.



Range names for an Excel list (like the simple one below) can be used to simplify references and in calculations.

In this example, select the list (the range B3:C7 in the illustration below) and use *Insert, Name, Create* to open Excel's "Create Names" dialog. Excel guesses where the likely names are in relation to the data. In this case, the data is in C4:C7 and the names come from the top row and left column.

	A	B	C	D	E	F	G	H
2								
3			January					
4		A	10					
5		B	15		10	=January A		
6		C	28		25	=January A + January B		
7		D	32					

Create Names ? X

Create names in _____

Top row

Left column

Bottom row

Right column

OK Cancel

With names established, you can use a "shorthand" reference to refer to the numeric cells. Cell C4 can also be called **January A** since it falls at the intersection of those row and column names. In like manner, Cell C5 can also be referred to as **January B**.

Cell E5 contains the formula =**January A** and displays the value 10.
 Cell E6 contains the formula = **January A + January B** and displays the value 25.

There's another way to name a range whose values you intend to use in a calculation: By using the special "Label Ranges" dialog. In this example, imagine you have a list of values like the one at right, with the label "Year99" at the top of the column. Select the range (including the label) and choose *Insert, Name, Label* to open the "Label Ranges" dialog.

Year99
10
30
50
50

Label Ranges ? X

Add label range _____

B13:B17 Add

Row labels Column labels

Existing label ranges

B13:B17 Remove

Excel fills in the label range. Specify that you're using "Column labels" and click OK.

Use this method to specify ranges that contain column and row labels on your worksheet.

12		
13	Year99	
14		10
15		30
16		50
17		50
18		
19		
20		140
21		
22		240
23		
24		

You can now use the “label range name” in calculations.

For example, this formula:

=SUM(Year99)

returns the value 140.

The formula

=SUM(Year99, 100)

returns the value 240.

As a quicker alternative to using the *Insert, Name, Label* command, you can select a range (not including its header) and use the Name Box to assign a range name. Then use that range name in calculations, as above.

A named cell (or range) is treated as an absolute reference in a formula.

If you assign a cell or range a name and then want to change it, you can. But Excel offers no simple method. The only way to change a range name is to use *Insert, Name, Define*, add the new name, and then delete the old name.

✓ Using a Formula to Name a Range

The section above (Naming Cells & Ranges Used in Formulas) describes the usual methods used to create names in a worksheet. However, you can *also* make use of a special range-naming option: Name a range by using a formula.

When might you want to do this? A common situation is this: You want to refer to a range whose length may change over time. You don't want to have to re-name the range each time its length changes. However, if you name the range using a dynamic formula, the formula will adjust when the range length adjusts, and the name will always refer to the entire set of data.

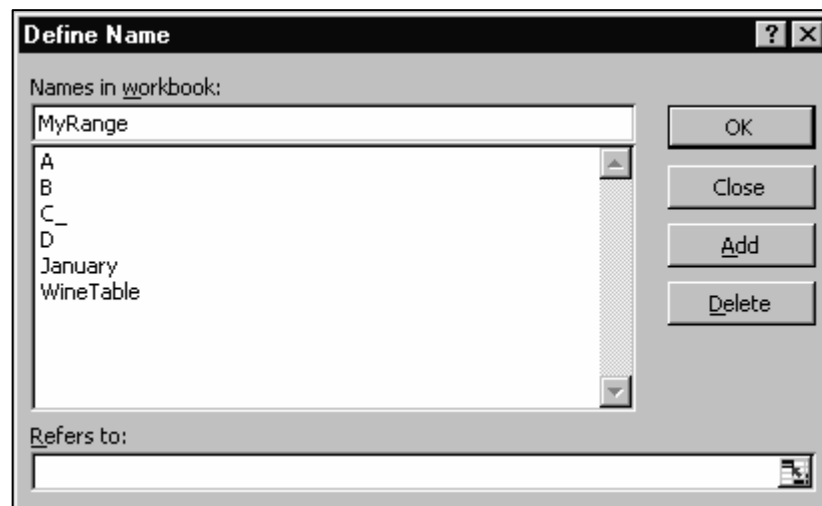
Here's how to accomplish this:

1. Locate your list in some area of the worksheet. Below is a simple, three-column list.

The current list is in the range B5:D9.

	A	B	C	D	E
4					
5		1	10	3	
6		2	20	6	
7		3	30	9	
8		4	40	12	
9		5	50	15	
10					

2. Without having selected the list, issue the commands *Insert, Name, Define* to open the "Define Name" dialog. Supply a name for the range when prompted.



In the example above, I supplied the name **MyRange**.

3. In the "Refers to" box, enter not the reference to the current range (B5:D9), but instead, a formula that will dynamically define the range.

The formula will take this format:

=OFFSET(Sheet1!\$B\$5, 0,0, COUNTA(Sheet1!\$B:\$B),3)

How the formula works:

The first argument of the OFFSET function is the anchor cell: In our example, B5. This cell should be the upper-left-hand cell in the range, either a data cell or the first header cell if your list has headers. Note that the sheet name is included in this reference and the reference to the anchor cell is absolute.

The second argument indicates how many rows down to move from the offset cell to begin the range. In our example, since 5 is the first row of the range, we move zero rows.

The third argument indicates how many columns to the right to move from the offset cell to begin the range. In our example, since B is the first column of the range, we move zero columns.

The fourth argument tells how many rows belong in the range. Instead of providing a static value here, use the COUNTA function. Supplying the COUNTA function with the reference \$B:\$B indicates that it should count all the occupied rows in the B column. If more or fewer values are included in the B column, COUNTA(Sheet1!\$B:\$B) will keep track of them. *It's important not to have extraneous data beneath the dynamic range.* Note also that the sheet name is included and the column B reference is absolute.

The fifth and final argument tells how many columns to include in the range. In this example, three columns.

With the formula complete, click the *Add* button to assign the name to the range.

- To test the formula as a range name, click F5 to open Excel's "Go To" dialog. In the "Reference" box, enter the range name and click OK. Excel should highlight the range.

	A	B	C	D
4				
5		1	10	3
6		2	20	6
7		3	30	9
8		4	40	12
9		5	50	15



Then, add records to the list (or subtract records) and again, use the Go To function with the dynamic range name. Even though the range size has changed, Excel should again highlight the entire range.

	A	B	C	D
4				
5		1	10	3
6		2	20	6
7		3	30	9
8		4	40	12
9		5	50	15
10		6	60	18
11		7	70	21
12		8	80	24
13		9	90	27
14		10	100	30
15				

Notes:

- A dynamic range name constructed in this way *will* appear in the list of worksheet range names when you choose *Insert, Name, Define*. However it *will not* appear in the list of names in the drop-down Name Box on the formula bar.
- Because a dynamic named range is dependent on calculation, it can only be referenced in an open workbook.

✓ Understanding Relative, Absolute, & Mixed Addressing

You may often want to use the same formula in one or more places in a worksheet. It's most efficient to build the formula one time and then copy it to the other locations where you need it. If you copy a formula, you must understand Excel's relative and absolute addressing.

When you copy a formula Excel uses relative addressing as the default. That is, when you copy the formula to a new location Excel adjusts the cell references in the copied formula relative to its new location.

In the illustration at left below, the formula in Cell D4 is used to calculate the total sales in January and February for Dept 1: **=B4+C4**. We need the same basic formula in Cells D5 and D6 for Departments 2 and 3. Although we could enter two new formulas, it's easier to copy the formula in D4 to these locations.

Point with the mouse to the "fill box" at the lower right-hand corner of Cell D4 and drag down through Cells D5 and D6 to copy the formula.

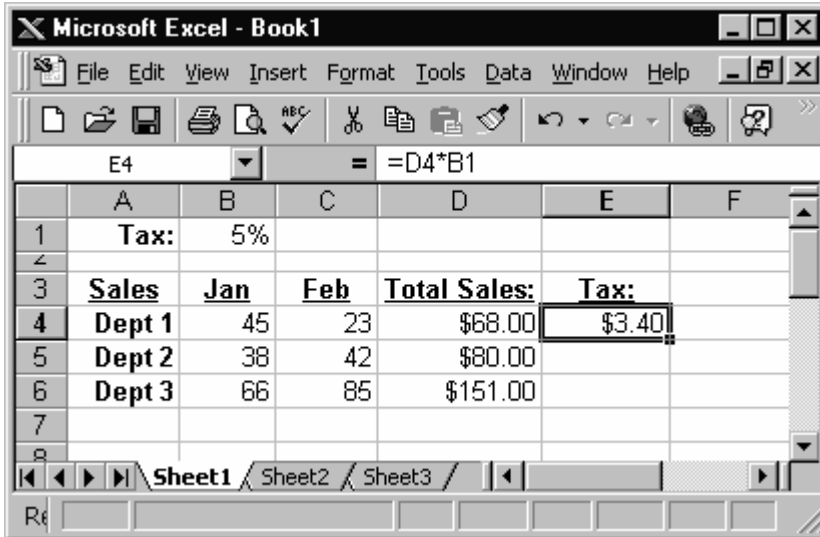
	A	B	C	D
1	Tax:	5%		
3	Sales	Jan	Feb	Total Sales:
4	Dept 1	45	23	\$68.00
5	Dept 2	38	42	
6	Dept 3	66	85	

	A	B	C	D	E
1	Tax:	0.05			
3	Sales	Jan	Feb	Total Sales:	
4	Dept 1	45	23	=B4+C4	
5	Dept 2	38	42	=B5+C5	
6	Dept 3	66	85	=B6+C6	
7					
8					

Sum=\$299.00

For each copied formula, Excel automatically adjusted the cell references to refer to the data in the correct row. This is Excel's default mode when copying formulas. It's **relative addressing**.

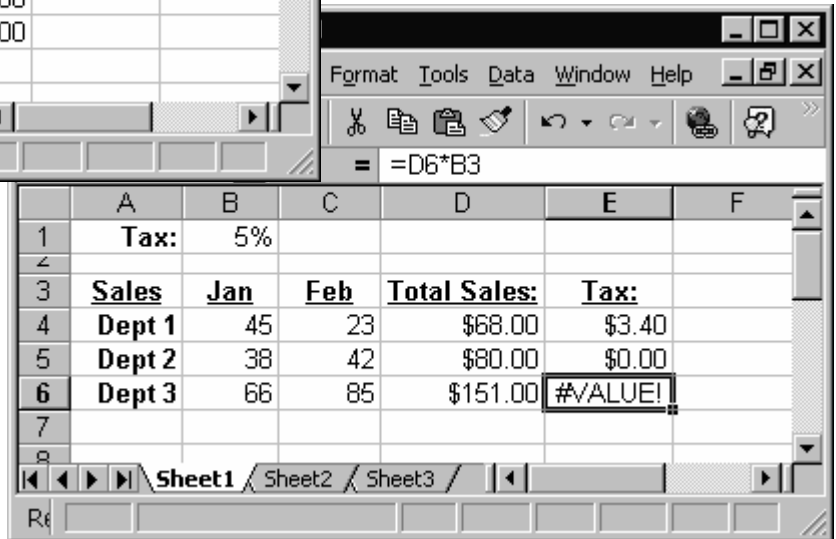
There may be occasions, however, when you want to override Excel's relative addressing default. In the example below, the formula in Cell E4 (in the Tax column) multiplies the Dept 1 Total Sales value (Cell D4) and the 5% value (Cell B1). The result is correct for this row.



However, if we copy the formula in E4 down to E5 and E6 for Depts 2 and 3, the result for those rows is *not* correct.

In the absence of any other instruction, Excel has again used relative addressing in the formula copy. The formulas in Cells E5 and E6 read as follows:

=D5*B2
=D6*B3

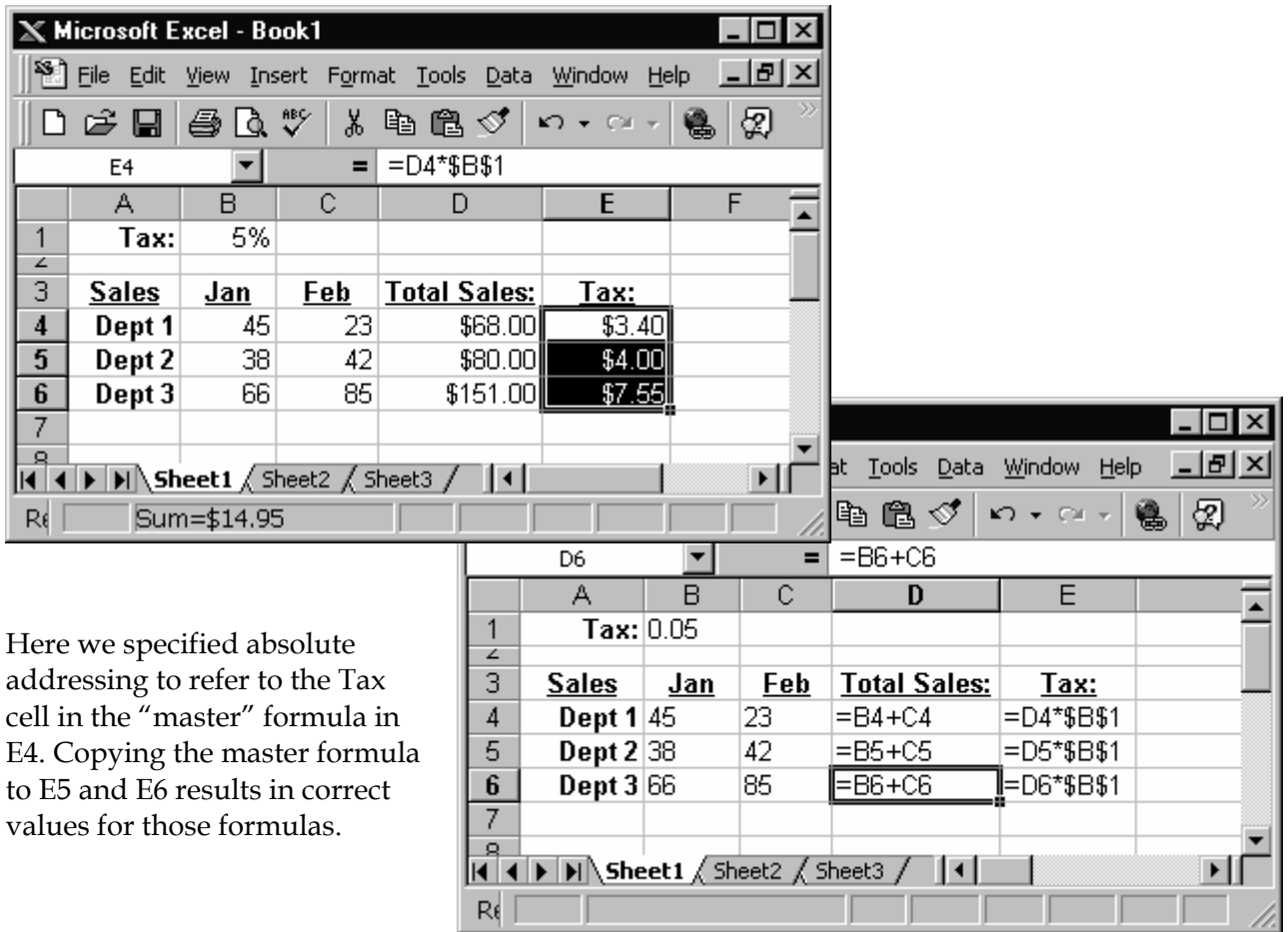


The first reference in each of these formulas is OK. We *do* want the copied formulas to refer to the Total Sales values for their respective rows (Cells D5 and D6). The problem is with the reference to Tax in Cell B1. The master formula in Cell E4 correctly reads **=D4*B1**. But the copied formula in E5 refers to Cell B2 (an empty cell), resulting in a calculation of \$0.00. And the copied formula in E6 refers to Cell B3 (which holds the text value "Jan"), resulting in a #VALUE error statement.

To make sure the copied formulas in this case refer to the correct Tax cell, use **absolute addressing** for the reference to Tax. Absolute addressing in a formula fixes the reference to a cell no matter where the formula is copied. Absolute addressing can apply to a single cell, a range of cells, or to one, several, all, or none of the cells referred to in a formula.

Specify absolute addressing with a dollar sign (an arbitrarily selected symbol) before the row reference and the column reference. For example, a relative reference in a formula to the Tax value in Cell B1 is written as **B1**. An absolute

reference in a formula to the Tax value is written as **\$B\$1**. (It's also possible to "fix" just the row but not the column by writing **B\$1** or just the column and not the row by writing **\$B1**. This is called **mixed addressing**.)



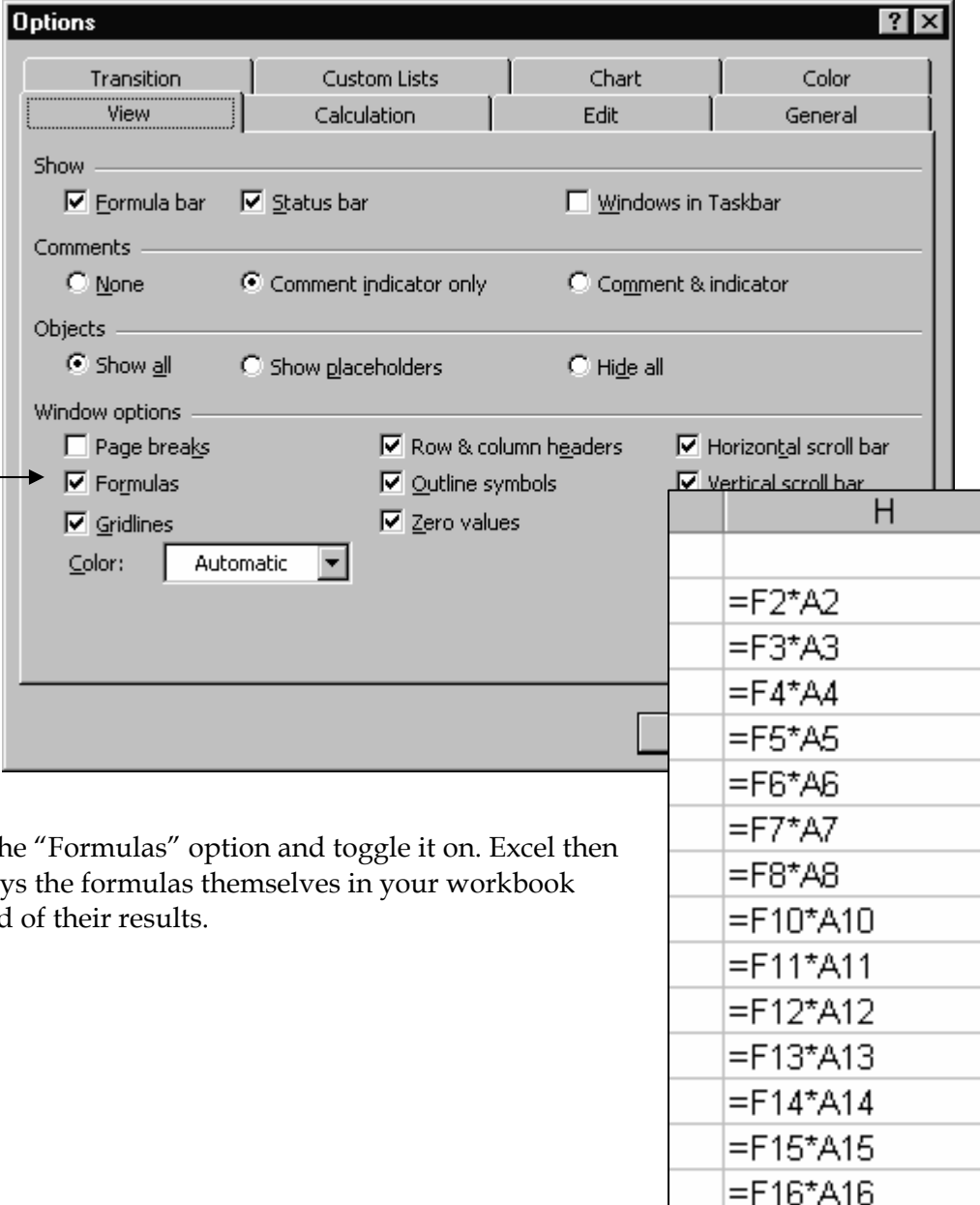
Here we specified absolute addressing to refer to the Tax cell in the "master" formula in E4. Copying the master formula to E5 and E6 results in correct values for those formulas.

Tip: When positioned over a cell or range reference on the formula bar, the F4 key cycles through the four addressing options: completely relative, completely absolute, absolute row but not column, and absolute column but not row. That is: **B1**, **\$B\$1**, **B\$1**, and **\$B1**.

✓ How to Display Formulas in a Worksheet

By default, Excel displays the substance of a formula in the formula bar, but the results of the formula in the worksheet itself. You may occasionally want to have Excel display the formulas in the worksheet, so you can check them or for documentation.

Open Excel's "Options" dialog by choosing *Tools, Options*. Then choose the "View" tab.



The screenshot shows the "Options" dialog box with the "View" tab selected. The "Formulas" checkbox under "Window options" is checked. An arrow points to this checkbox. To the right, a portion of a worksheet is visible, showing column headers H and rows with formulas like =F2*A2 through =F16*A16.

	H
	=F2*A2
	=F3*A3
	=F4*A4
	=F5*A5
	=F6*A6
	=F7*A7
	=F8*A8
	=F10*A10
	=F11*A11
	=F12*A12
	=F13*A13
	=F14*A14
	=F15*A15
	=F16*A16

Find the "Formulas" option and toggle it on. Excel then displays the formulas themselves in your workbook instead of their results.

✓ Array Formulas

An array formula can perform multiple calculations and then return either a single result or multiple results. Array formulas act on one or more sets of values known as array arguments. Each array argument must have the same number of rows and columns. You create array formulas in the same way that you create other formulas, except you press CTRL+SHIFT+ENTER to enter the formula.

In some cases Excel must perform several calculations to generate a **single result**. For example, the worksheet below shows that a company has regional offices in Europe and North America. Each region has three product divisions. You can find the average revenue per product division for Europe in 1999 using a single formula, provided you enter the formula as an array.

	B	C	D	E	F
3			1999	2000	
4	Electronics				
5		Europe	100,600	161,000	
6		North America	123,100	198,200	
7		<i>Electronics Total</i>	223,700	359,200	
8	Acoustics				
9		Europe	129,200	160,700	
10		North America	150,500	190,100	
11		<i>Acoustics Total</i>	279,700	350,800	
12	Pro Studio Equipment				
13		Europe	89,900	153,900	
14		North America	112,300	190,700	
15		<i>Pro Studio Equipment Total</i>	202,200	344,600	
16		106,566.67	Average of European figures		
17					

Cell C16 contains this array formula

=AVERAGE(IF(C5:C14="Europe",D5:D14))

It's important to note that the formula was entered not by using the Enter key, but by pressing CTRL+Shift+Enter. That special key sequence tells Excel to treat the formula as an array.

The formula finds the cells in the range C5:C14 that contain the text "Europe" and then averages the corresponding cells in the range D5:D14.

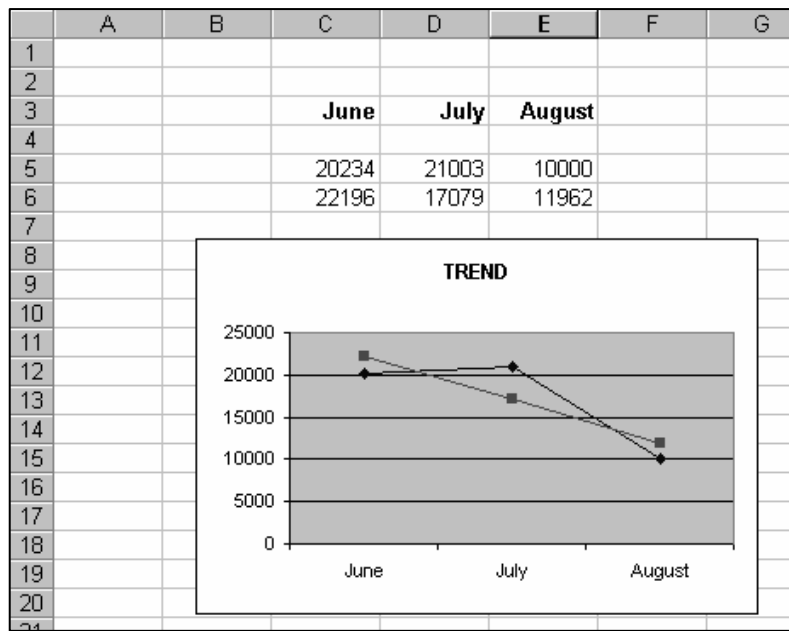
To calculate **multiple results** with an array formula, you must enter the array into a range of cells that has the same number of rows and columns as the array arguments.

In the following example, given a series of three sales figures (in row 5) for a series of three months (in row 3), the TREND function determines the straight-

line values for the sales figures. To display the results of the formula, select the three cells (C6:E6) before entering the formula.

	A	B	C	D	E	F
1						
2						
3			June	July	August	
4						
5			20234	21003	10000	
6						
7						

Then, when you enter the formula =TREND(C5:E5) as an array formula, it produces three separate results, based on the three sales figures and the three months.



In an array formula, where you might usually use a reference to a range of cells, you can instead *type* the array of actual values contained within the cells. The array of values you type is called an **array constant**. Use it when you don't want to enter each value into a separate cell on the worksheet. To create an array constant, you must do the following:

1. Enter the values directly into the formula, enclosed in braces ({ })
2. Separate values in different columns with commas (,)
3. Separate values in different rows with semicolons (;)

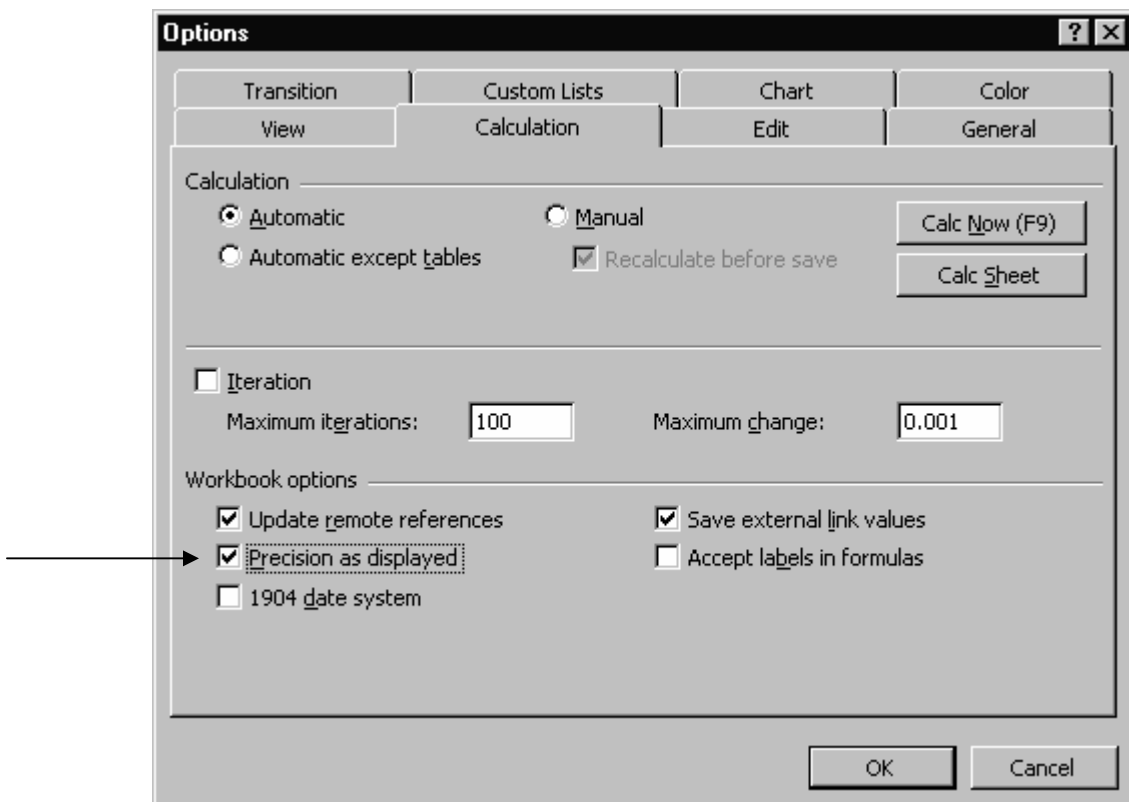
For example, you can enter {10,20,30,40} in an array formula instead of entering 10, 20, 30, 40 in four cells in one row. This array constant is known as a 1-by-4 array and is equivalent to a 1-row-by-4-column reference. To represent the values 10, 20, 30, 40 in one row and 50, 60, 70, 80 in the row immediately below, you would enter a 2-by-4 array constant: {10,20,30,40;50,60,70,80}.

✓ Precision in Calculations

Regardless of the number of digits displayed, Excel stores numbers with up to 15 digits of precision. If a number contains more than 15 significant digits, Excel converts the extra digits to zeros (0).

You can change the precision of the calculations in a workbook by directing Excel to use the displayed (formatted) values instead of the underlying values.

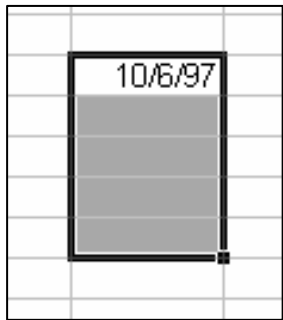
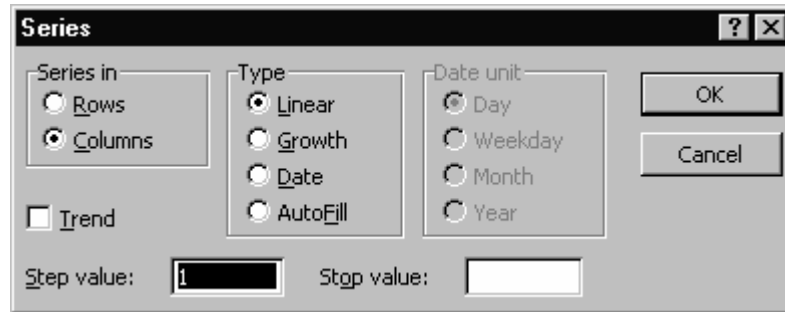
To change the default, choose *Tools, Options* and select the “Calculation” tab. Under “Workbook options” on that tab, toggle on the **Precision as displayed** check box.



Use caution with this option, since Excel permanently changes any constant values on the worksheets in the workbook. If you later decide you want to calculate with full precision, the original underlying values cannot be restored.

✓ Edit, Fill, Series

Excel's *Edit, Fill* command allows you to quickly copy data. A useful variation on the plain *Edit, Fill* is the *Edit, Fill, Series* command. This command opens the "Series" dialog which allows for more than a simple copy.



Enter the beginning value in a cell of your spreadsheet. At left, the beginning value is a date. Then select the cells beneath (Series in Columns) or to the side (Series in Rows) of the initial value that you want to fill with series values.

Choose the type of series (Linear, Growth, Date, Autofill). Depending on this selection, also select a Step value, Stop value, or Date unit.

Two *Edit, Fill, Series* examples:

	A	B
1	10/6/97	
2	10/6/98	
3	10/6/99	
4	10/6/00	
5	10/6/01	
6		

Date, incremented by year.

	A	B
1	3.41	
2	18.755	
3	103.1525	
4	567.3388	
5	3120.363	
6		

Growth with a step value of 5.5.

✓ Quick Calculations with the Status Bar

Excel's Status Bar can provide you with on-the-fly calculations for values in your worksheet. The Status Bar is located across the bottom of the workspace. If your Status Bar doesn't display, turn it on in Excel's "Options" dialog. Choose *Tools, Options* and select the "View" tab. Toggle on the "Status bar" option.

The image shows two screenshots from Microsoft Excel. The top screenshot is the 'Options' dialog box, with the 'View' tab selected. The 'Status bar' checkbox is checked and circled in red. An arrow points from this checkbox to the bottom screenshot. The bottom screenshot shows the Excel worksheet with a range of cells (B2:B6) highlighted. The Status Bar at the bottom of the window displays 'Average=\$457', which is also circled in red.

Highlight a range of numbers in your worksheet and the Status Bar, by default, reports the sum of those numbers.

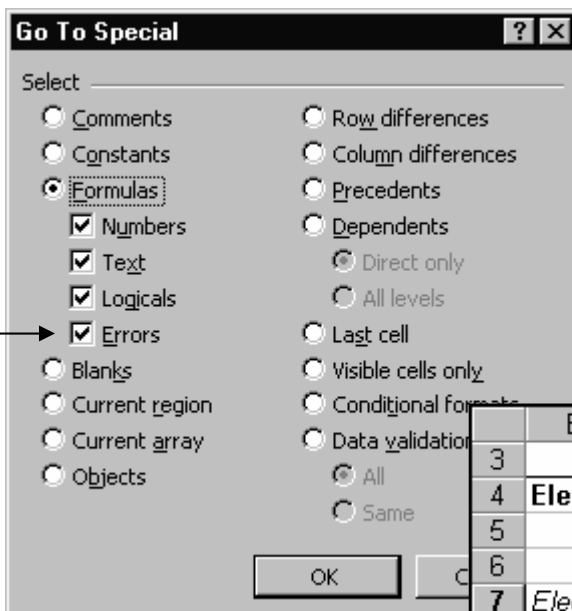
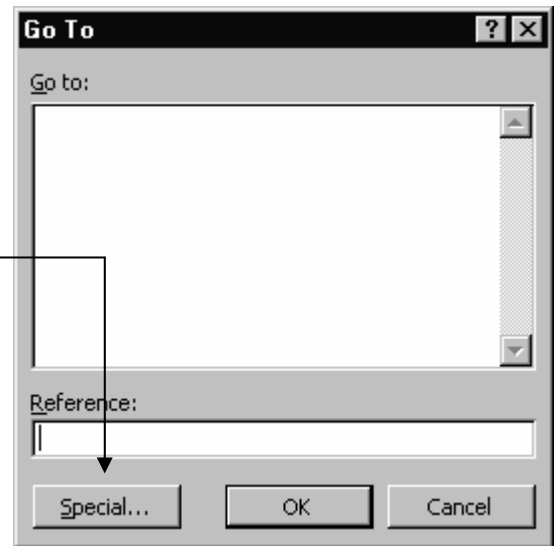
Right-clicking the sum report on the Status Bar to display a drop-down list of other calculation options: Average, Count, Count Nums, Max, and Min.

	A	B	C	D	E	F
1		Sales				
2	January	\$800				
3	February	\$500				
4	March	\$300				
5	April	\$250				
6	May	\$435				
7						
8						
9						

✓ Finding Formulas

Excel's *Go To* feature provides a quick way to identify all the calculations in your worksheet. Click *Edit, Go To* or hit F5 to open the *Go To* dialog.

Click the *Special* button on the *Go To* dialog to open the "Go To Special" dialog.



In the "Go To Special" dialog, choose "Formulas" and the type of data you want to select. Then click *OK*.

Excel highlights all the formulas of the type you selected.

Using the *Go To, Special*, "Errors" option to find incorrect formulas can be useful when debugging a spreadsheet.

	B	C	D	E	F
3			1999	2000	
4		Electronics			
5		Europe	100,600	161,000	
6		North America	123,100	198,200	
7		<i>Electronics Total</i>	223,700	359,200	
8		Acoustics			
9		Europe	129,200	160,700	
10		North America	150,500	190,100	
11		<i>Acoustics Total</i>	279,700	350,800	
12		Pro Studio Equipment			
13		Europe	89,900	153,900	
14		North America	112,300	190,700	
15		<i>Pro Studio Equipment Total</i>	202,200	344,600	
16		106,566.67	Average of European figures		
17					

✓ Writing and Using Formulas with Links

Linking allows you to use data stored in different worksheets and workbooks in your formulas. Linking is especially useful when it's not practical to keep large worksheet models together in the same worksheet or workbook.

How to create a formula that uses data on another worksheet or workbook

1. If you're linking to a new workbook, save the new workbook before creating the link.
2. In the "dependent" workbook (the one that will contain the formula), select the cell in which you'll enter the formula and start the formula by typing an equals sign. Depending on the formula or function you're using, continue typing until you're ready to access the external reference.
3. To create a link to values in another worksheet in the active workbook, click the worksheet that contains the cell (or cells) you want to access and select that cell. If you're creating a link to a value in another workbook, switch to that workbook and then select the cell in that workbook. Excel inserts the correct linking reference in your formula.
4. Continue typing the formula. When it's complete, hit the Enter key.

Linking syntax for a different worksheet in the same workbook

In this example, the AVERAGE worksheet function calculates the average value for the range B1:B10 on the worksheet named Marketing. The Marketing worksheet is in the same workbook.

```
=AVERAGE(Marketing!B1:B10)
```

The sheet name "Marketing" precedes the range reference. An exclamation mark separates the sheet name from the range reference.

Linking syntax for a worksheet in a different workbook

In the example below, the Marketing worksheet is in a different workbook, named BUDGET.

```
=AVERAGE([Budget.xls]Marketing!B1:B10)
```

The workbook name precedes the worksheet name. The workbook name is enclosed in square brackets.

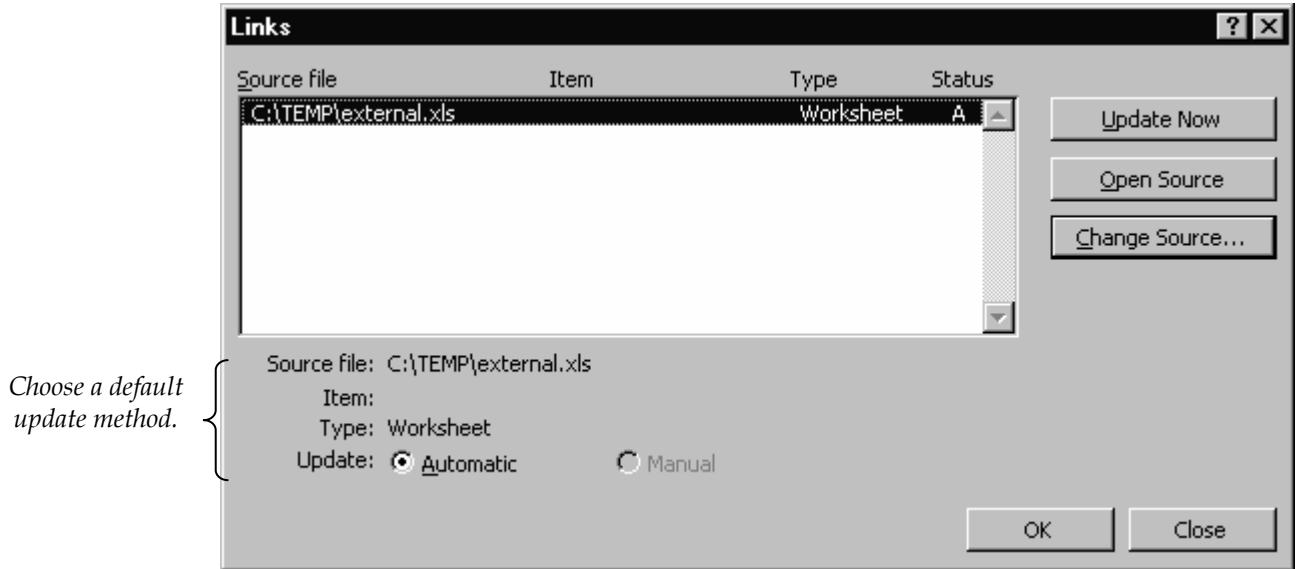
When you view this formula later, if the Budget.xls workbook is closed the external workbook name displays the entire path. For example, if Budget.xls resides on C:\TEMP, the formula displays as follows:

```
=AVERAGE('C:\TEMP\[Budget.xls]Marketing'!B1:B10)
```

Note the single quote marks that surround the entire external reference up to the exclamation point.

If the source data in a different workbook changes

If the source cell in a link changes (for example, it's moved or its value changes), Excel updates the linked formula automatically only if the workbook containing the link (the dependent workbook) is open. If the dependent workbook is *not* open when you change the source workbook, you can manually update the link references later. Open the dependent workbook and choose *Edit, Links* to open the "Links" dialog.



In the "Links" dialog find the "Source file" list, click the source for the linked object, and then click the *Update Now* button. To update links in a formula every time you open the file that contains the formula or any time the original information changes (while the dependent file is open), choose "Automatic" as the default update method. To update a workbook with links only when you use the "Update Now" button, choose the "Manual" update method.

Examples of when to use links

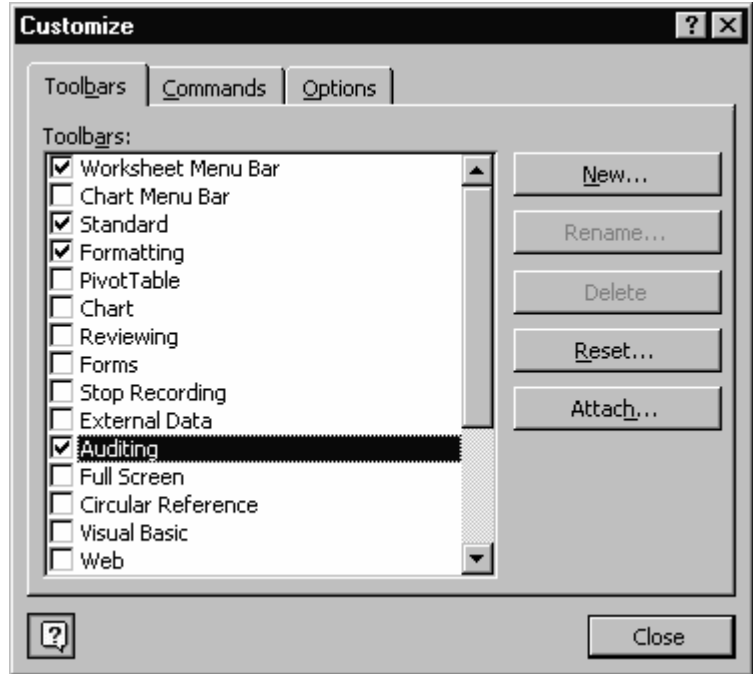
- Link workbooks from several users or departments and then integrate the key data into a summary workbook. Then when the source workbooks are changed, you won't have to manually change the summary workbook. For example, a group of sales offices may track data in individual workbooks; the data is then rolled into a workbook that summarizes the data at the district level, which is then rolled into a workbook that summarizes data at a regional level. You have a hierarchy of links.
- Streamline a large, complex model by breaking it down into a series of interdependent worksheets or workbooks. Then work on sections of the model without opening all of its related sheets. Smaller workbooks are easier to change, don't require as much memory, and are faster to open, save, and calculate.

✓ Auditing Your Formulas

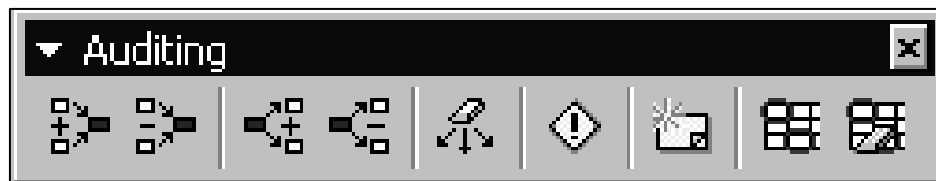
Locate the cells that supply data for formulas and find cells that depend on values in other cells by using Excel's Auditing toolbar.

The Auditing toolbar isn't in the regular list of toolbars. To display it, click *Auditing* on the Tools menu and then choose *Show Auditing Toolbar*.

Or, click *Tools, Customize* to open the "Customize" dialog box. Locate **Auditing** in the list and toggle it on.



The Auditing toolbar opens and floats on the worksheet surface.

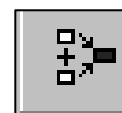


Use the tools on the Auditing toolbar to locate problems and display cell relationships.

For example, a circular reference occurs when a formula mistakenly refers to itself and thus can't be resolved. Click the problem cell and use the *Trace Error* button on the Auditing Toolbar to locate source of the error.



Or, click the cell whose dependents or precedents you want to locate and use the trace precedents or trace dependents icons on the Auditing Toolbar. Excel draws arrows on the worksheet to show relationships between cells. Use the erase precedent arrows icon or the erase dependent arrows icons to erase the arrows when you're through.



What the tracer arrows indicate

- Blue tracer arrows point to cells in the same worksheet that provide data to the formula in the selected cell.
- Red tracer arrows point to cells that cause errors.
- If the selected cell contains a reference to another worksheet or workbook, a black tracer arrow points from a little worksheet icon symbol to the selected cell.

Selecting traced cells

To select the cell at the other end of a tracer arrow, double-click the arrow. To select a precedent cell in another worksheet or workbook, double-click the black arrow and then double-click the reference you want in the “Go to” list that displays. If the precedent cell is in another workbook, that workbook must be open before you can select the precedent cell.

Limitations of the Auditing toolbar

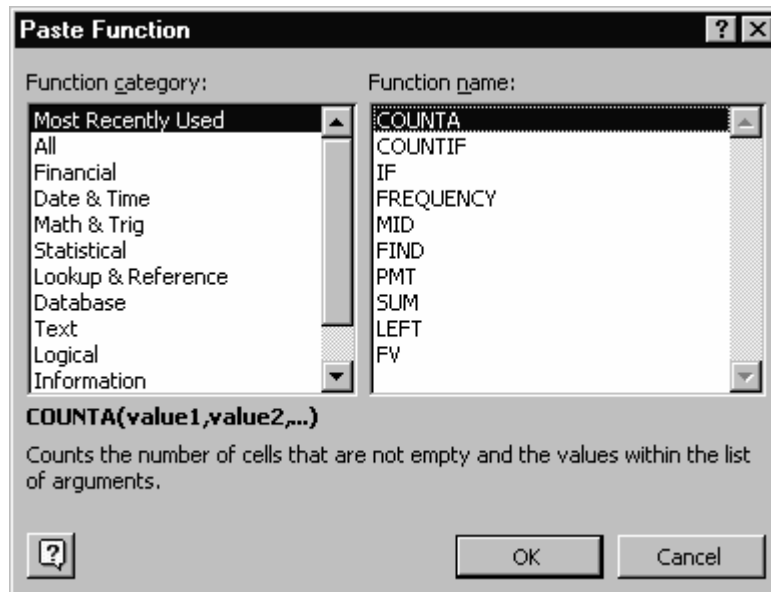
The Auditing toolbar isn’t available if your worksheet is protected. The Auditing toolbar can’t trace these types of objects:

- References to text boxes, embedded charts, or pictures on worksheets
- PivotTable reports
- References to named constants
- Formulas located in another workbook that refer to the active cell if the other workbook is closed

II. Excel's Built-in Calculations

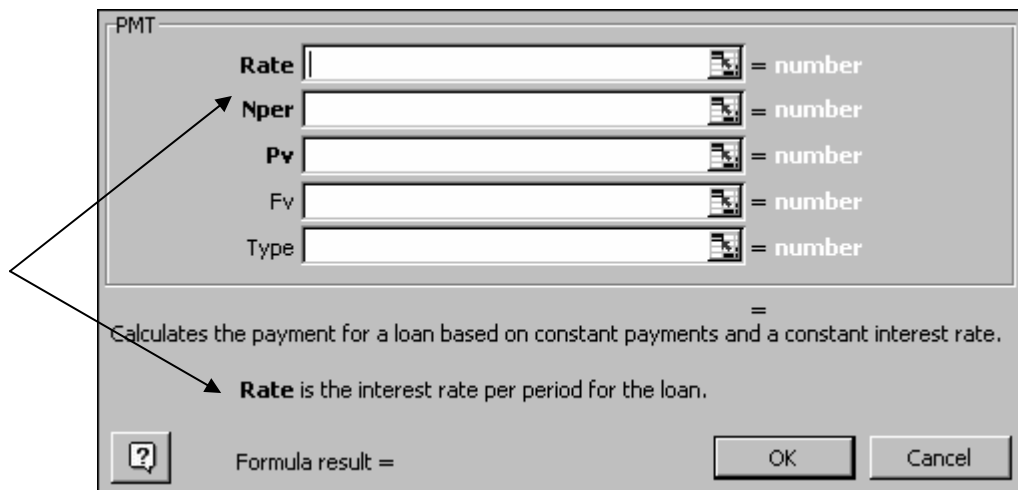
✓Using built-in functions

Excel has a large library of built-in formulas, called functions. If you already know a function you can enter it directly in your worksheet. Otherwise, click the *Function* button on the Standard Toolbar or choose *Insert, Function* from Excel's menus to open the *Paste Function* dialog.



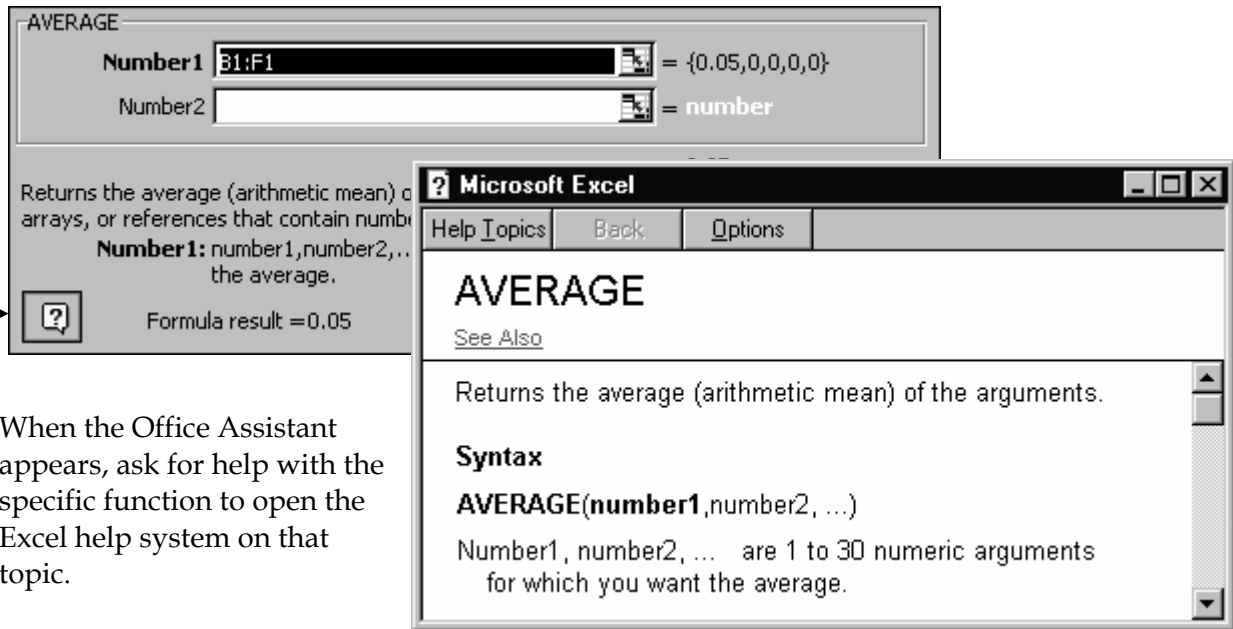
The left-hand side of the dialog displays function categories. Click a category name to see functions in that category in the list at right. Click a function in the list at right and click the *OK* button to open a help dialog for that function.

For example, select the Financial category and the PMT function to open this dialog. For whatever box your insertion point is in, a description is displayed.



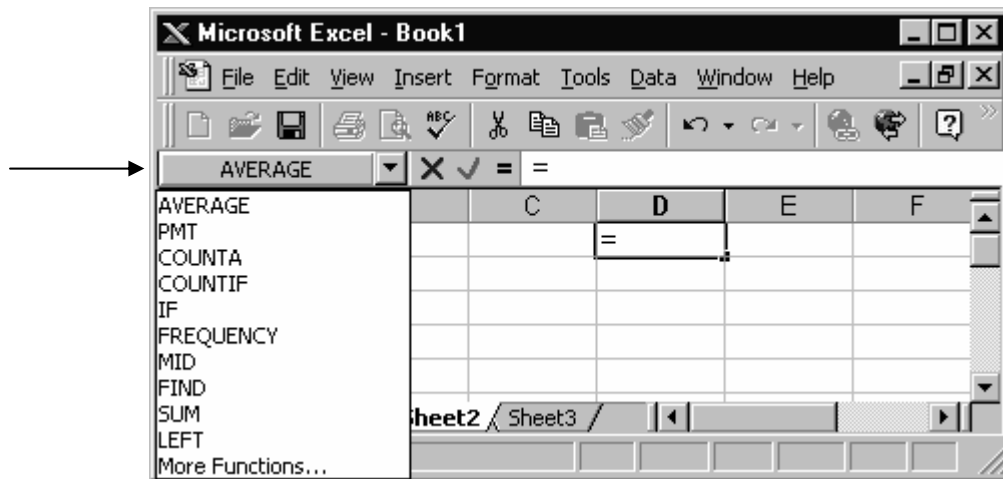
Excel remembers the functions you last used and groups them in a category named *Most Recently Used*. If you're not sure what category a function you want might be in, select the *All* category. Then all the functions list in the box at right, in alphabetical order.

When you're working with the dialog for a specific function, get more help about that function by clicking the online help box at the lower left-hand corner of the dialog.



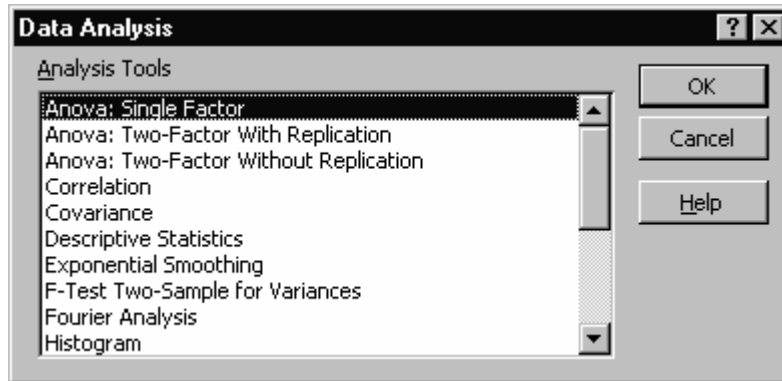
When the Office Assistant appears, ask for help with the specific function to open the Excel help system on that topic.

Another way to access Excel's functions is to start entering a formula by typing an equals sign and then using the drop-down list of functions that appears in the Name Box on the Formula bar.



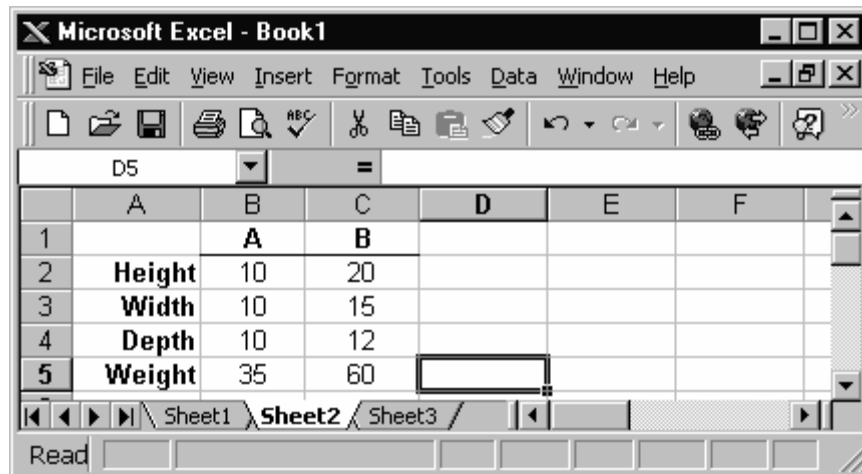
✓ The Data Analysis Toolbox

Excel includes a set of data analysis tools packaged into its “Analysis ToolPak”. Use these tools to save steps when you develop complex statistical analyses. The commands *Tools, Data Analysis*¹ open the *Data Analysis* dialog that displays the list of statistical analysis tools.



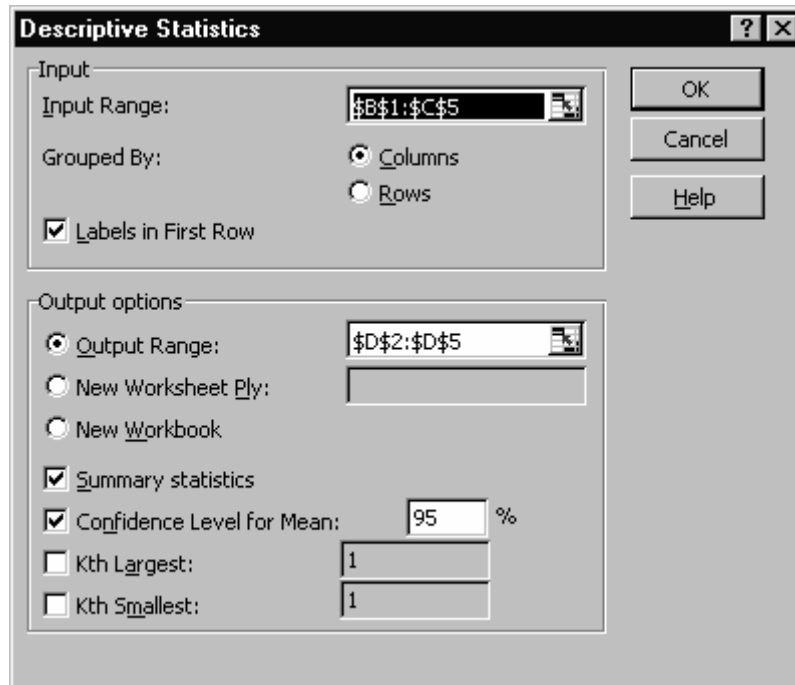
Select a tool from the list and then provide the data and parameters (if necessary) for the analysis. The tool displays the results in an output table. Some tools generate charts in addition to output tables.

For example, to use the *Descriptive Statistics* tool, first assemble the data to analyze on your worksheet.

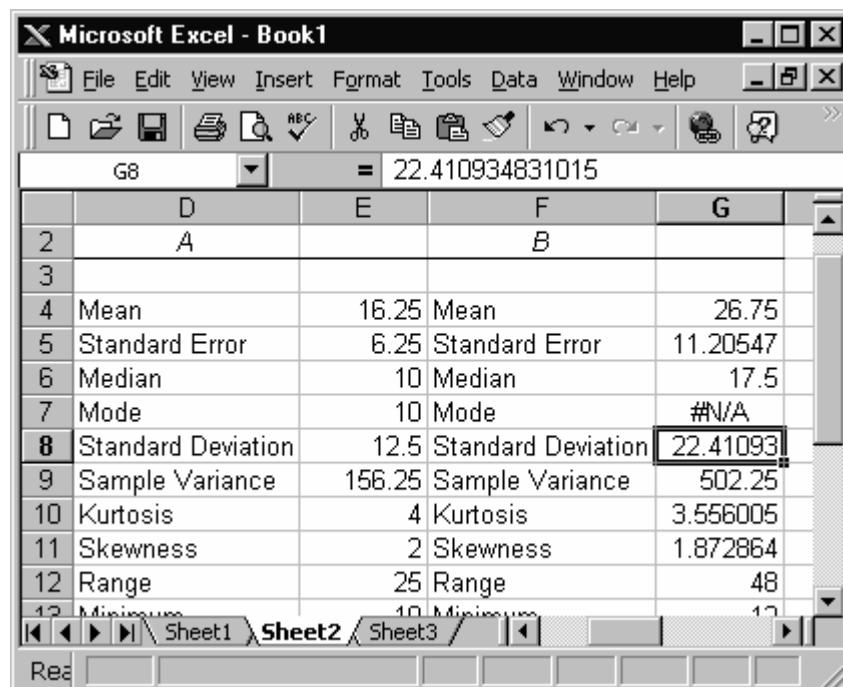


¹ Excel’s Analysis Tools are an add-in. If they’re not available in your installation of Excel, click *Tools, Add-Ins* and select *Analysis Toolpak*. If the Analysis Toolpak isn’t an option, rerun Excel’s setup program.

Invoke the *Descriptive Statistics* tool from the Analysis Toolpak. A dialog specific to that tool opens.



Complete the dialog and click *OK* to let the tool generate results. In the illustration above, we specified an output range in the same worksheet for the results data.



✓ IF and the Logical Functions

Excel's IF function is probably the most important of the set of Excel's logical functions. Excel's other logical functions are AND, NOT, OR, FALSE and TRUE.

The IF function checks a condition that must be either true or false. If the condition is true, the function returns one value; if the condition is false, the function returns another value.

The IF function has three arguments: the condition you want to check, the value to return if the condition is true, and the value to return if the condition is false. The syntax of the IF statement is:

=IF(logical_test,value_if_true,value_if_false)

For example, the formula =IF(12>2,"Correct","Not Correct") would return the text value **Correct**. The formula =IF(12<2,"Correct","Not Correct") would return the text string **Not Correct**.

The condition part of the IF statement can use any comparison calculation operator. That is, =, >, <, >=, <=, or <>.

Up to seven IF functions can be nested as value_if_true and value_if_false arguments to construct more elaborate tests. However, a statement with more than one or two embedded IF functions is hard to read and may be unnecessarily complicated.

For example, using the data at left, you could use these nested IF statements to return the correct grade:

If score is	Return
> 89	A
80 to 89	B
70 to 79	C
60 to 69	D
< 60	F

```
IF(Score>89,"A",  
    IF(Score>79,"B",  
        IF(Score>69,"C",  
            IF(Score>59,"D",  
                "F")  
        )  
    )  
)
```

Four IF statements are included here. In the first one, a second IF statement is included in place of the third parameter. In the second IF statement, another IF statement is included in place of the third parameter. And so on.

Written on a single line, the statement would look like this:

IF(Score>89,"A", IF(Score>79,"B", IF(Score>69,"C", IF(Score>59,"D", "F"))))

Only the first part of the statement would be evaluated for a score of 90, but the entire statement would need to be evaluated for a score of 58.

Excel permits up to seven levels of nesting in an IF statement.

The AND Function

The AND function can handle up to thirty conditions that can evaluate to true or false. This function requires that *all* its arguments evaluate as true in order for AND to evaluate to **True**. For example, the formula =AND(1<5,10>2) evaluates to **True**. But the formula =AND(1<5,12<2) evaluates to **False**.

The OR Function

Like the AND function, the OR function can handle up to thirty conditions. However, the OR function requires that only *one* of the arguments evaluate as true in order to return true. So =OR(1<5,12<2) evaluates to **True**.

The NOT Function

The NOT function changes a TRUE outcome to a FALSE one and vice versa. For example, =NOT(12>2) returns **False**.

Excel has additional functions you can use to analyze your data based on a condition. For example, to count the number of occurrences of a string of text or a number within a range of cells, use the COUNTIF worksheet function. To calculate a sum based on a string of text or a number within a range, use the SUMIF worksheet function.

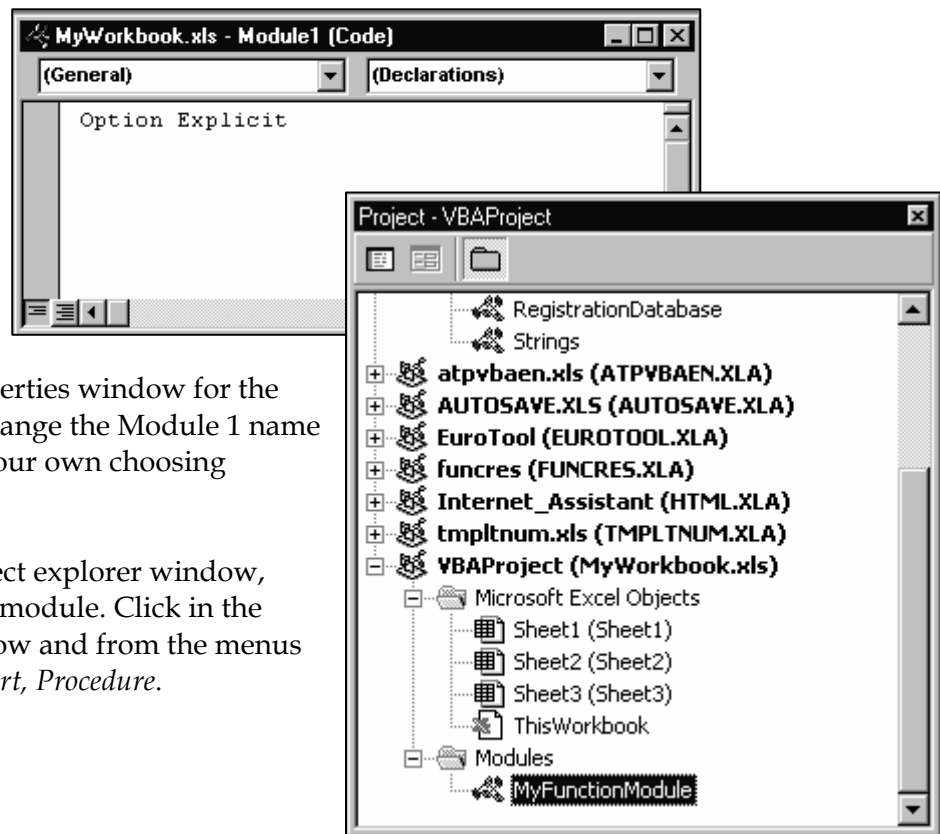
✓ An Introduction: Writing Your Own Functions

Although Excel has a wide array of built-in functions, you may find that you need a calculation that Excel doesn't provide. If you're somewhat familiar with Excel's Visual Basic for Applications (VBA), you can build your own functions, called User-Defined-Functions (UDFs). Like Excel functions, the functions you build perform calculations and return values.

This note is a sketch of how to get started defining your own function. If this capability looks useful, consult a good VBA reference for a complete explanation.

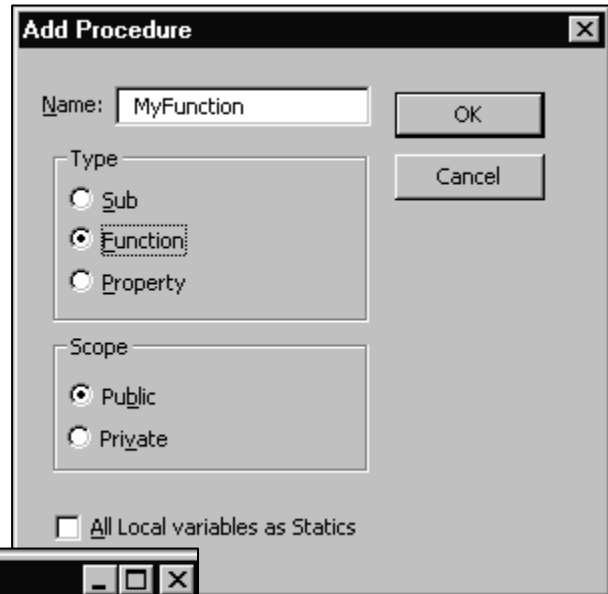
How to get started

1. Open a new workbook in Excel and save it.
2. Open the VBA environment (ALT+F11) and select the VBA Project that has your workbook name.
3. In the Properties window, change the VBA Project name to reflect your function (optional).
5. Select that project in the Project Explorer window and from the VBA menus choose *Insert, Module*.

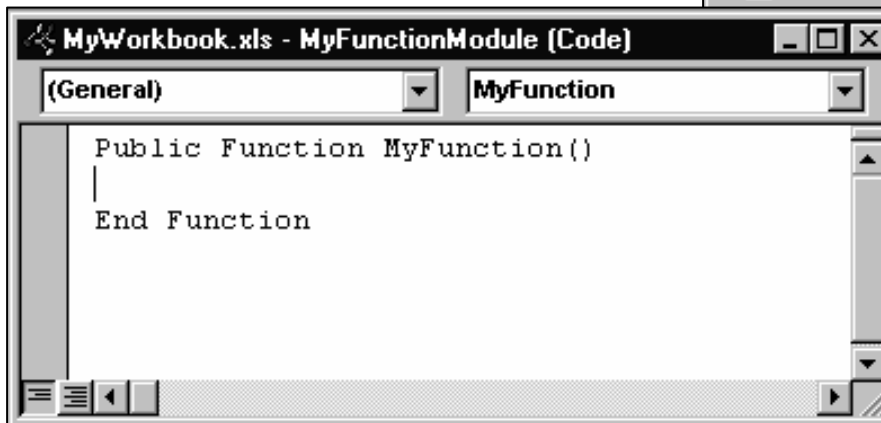


6. In the properties window for the module, change the Module 1 name to one of your own choosing (optional).
7. In the Project explorer window, choose the module. Click in the code window and from the menus choose *Insert, Procedure*.

8. In the "Add Procedure" dialog that displays, provide a function name, indicate that this is a function (not a subroutine). Leave the scope as "Public". Click *OK*.



9. VBA provides an empty function procedure for you to fill.



An example of a simple function's contents:

```
Public Function JCalc(X As Integer, Y As Variant, Z As Variant)
As Variant
    'Y and Z can be specific values or cell references or ranges.
    'Assume that the last value of i is 1 greater than X, or B5.
    Dim i As Integer, Total As Variant
    Total = 0
    i = 1
    Do Until i > X
        Total = Total + (Y ^ i / (1 + Z ^ i))
        i = i + 1
    Loop
    JCalc = Total
End Function
```

To call this function in Excel, use the function name and pass it variables. For example: **=JCALC(A1, B1, C1)**

III. Other resources

Many excellent guides to Excel are available. If you're a frequent user of the program you'll want to have at least one comprehensive reference on hand. Reference guides I've found useful include:

Excel 2000: The Complete Reference

Osborne

Kathy Ivens, Conrad Carlberg

ISBN 0-07-211967-5

Running Microsoft Excel 2000

Microsoft Press

Mark Dodge, Craig Stinson

ISBN 1-57231-935-6

Learn Excel 2000 VBA Programming

WordWare Publishing, Inc.

Julitta Korol

ISBN 1-55622-703-5

Microsoft Visual Basic for Applications

Course Technology

Diane Zak

ISBN 0-619-00020-1

Those looking for a more tutorial approach to learning Excel might want to check out:

Microsoft Excel 2000 Learning Kit

Microsoft Press

LearnIT, Mark Dodge, Craig Stinson

ISBN 0-7356-0914-4

Print and multimedia.

Microsoft Excel 2000 Step by Step

Catapult, Inc.

ISBN 1-57231-974-7