

FORMULAS AND FUNCTIONS

After familiarizing yourself with Excel's list management features (using it to record mailing lists and membership rosters, for example), you'll want to explore its extensive calculation capabilities. By combining the contents of specific cells with each other or constants, you can create *formulas*. For example, you can add two cells' contents, divide the contents of one cell by that of another, or multiply a cell's contents by a constant, such as a sales tax percentage or a commission rate.

You can also use Excel *functions* in your formulas. For instance, rather than laboriously adding the contents of several dozen cells, you can use the SUM function to generate a total for the range. In support of your calculation needs, Excel provides more than 300 built-in functions.

In this chapter, you'll learn the basics of combining cell references, constants, and functions into useful formulas. Techniques for troubleshooting formulas are also presented.

About Cell References

Although a formula can be composed solely of constants, such as `=12+5`, you'll seldom use Excel to perform such calculations. Almost all formulas include *cell references*, such as `=A2+5`. This formula is interpreted by Excel as: "Take the current contents of cell A2 and add 5 to it."

A1 reference style

By default, Excel worksheets use *A1 reference style* in which columns are lettered and rows are numbered. Each *cell address* is named for the intersection of the column and row in which the cell is located. For example, G7 is the cell found at the intersection of column G and row 7. A *range* is represented as a pair of addresses separated by a colon (:). For example, B3:B6 means all cells between cells B3 and B6 inclusive—that is, B3, B4, B5, and B6. Refer to **Table 10.1** for some additional examples.

3-D reference style

Excel also provides a *3-D reference style* that allows you to include cells and ranges from other sheets in your formulas, as well as perform calculations across workbook sheets:

- ◆ To include a cell or range from another sheet in a formula, you precede the cell or range address with the sheet's name followed by an exclamation point:

```
=Sheet2!a7-8
```

In this example, 8 is subtracted from the contents of cell A7 on Sheet2.

- ◆ To consolidate data across multiple sheets, precede the cell or range address with the sheet range:

```
=SUM(Sales1:Sales12!G50)
```

Table 10.1

A1 Reference Style Examples	
EXAMPLE	EXPLANATION
R5	Cell in column R, row 5
B3:E3	Cells B, C, D, and E in row 3
3:3	Row 3
F:F	Column F
5:8	Rows 5, 6, 7, and 8
A:C	Columns A, B, and C
A1:B3	All cells between cells A1 and B3 inclusive (A1, B1, A2, B2, A3, and B3)

	A	B	C	D	E
1	Student	Test 1	Test 2	Test 3	Total
2	Jonas	20	20	18	58
3	Thomas	18	16	19	53
4	Anthony	17	14	18	49
5	Michelle	15	14	16	45
6	Heidi	13	15	16	44
7	Adrian	14	9	11	34
8	Average	16.17	14.67	16.33	

```
f =SUM(Table1[@[Test 1]:[Test 3]])
```

Figure 10.1 In Table 1 (top), Total (column E) is a calculated column. When the formula is expressed in structured reference style (bottom), it is identical in every cell in the column.

	1	2	3
1	Date	Business Purpose	Destination
2	01/03/2006	Mail	Post Office
3	01/10/2006	Mail	Post Office

Figure 10.2 In R1C1 reference style, both rows and columns are numbered.

Table 10.2

3-D Reference Style Functions	
FUNCTION	DESCRIPTION
AVERAGE	Calculates the average (arithmetic mean)
COUNT	Counts the cells that contain numbers
MAX	Returns the largest value in referenced cells
MIN	Returns the smallest value in referenced cells
PRODUCT	Multiplies numbers in referenced cells
STDEV	Calculates the standard deviation, based on a sample
STDEVP	Calculates the population standard deviation
SUM	Adds numbers in referenced cells
VAR	Calculates the variance, based on a sample
VARP	Calculates the population variance

In this example, monthly sales are recorded in the first 12 sheets, each of which is named Sales, followed by the month number. Consolidating data this way assumes you have laid out the data in the sheets (Sales1–Sales12) in identical fashion; that is, the cell (G50, in this case) contains the appropriate number in each sheet, such as total monthly sales or Janice’s monthly commissions.

Structured reference style

Excel 2007 introduced *structured reference style*, a simplified means of addressing table data. When you create a formula in a table (a calculated column, for example), table-based structured references are automatically used rather than specific cell addresses (**Figure 10.1**).

✓ Tips

- When referring to a table cell in a formula, you can use structured or A1 reference style. If you point to the cell to add it to the formula, structured reference style is used.
- If you prefer, you can use *R1C1 reference style*, in which both rows and columns are numbered (**Figure 10.2**). R1C1 reference style is generally used in Excel scripts (called *macros*). To enable R1C1, click the File tab to display the Backstage and then click Options. In the Excel Options dialog box, select the Formulas category, click the R1C1 reference style check box in the Working with formulas section, and then click OK.
- In 3-D reference style, only certain functions can be used to consolidate data across sheets. For a list of these functions, see **Table 10.2**. Supported variants of these functions that can be applied to text and logical values include AVERAGEA, COUNTA, MAXA, MINA, STDEVA, STDEVPA, VARA, and VARPA.

Formula Essentials

This section presents the background information you'll need to create formulas.

Anatomy of a formula

A basic formula (**Figure 10.3**) consists of a combination of cell references, constants, and operators. (A *constant* is any data entered in a cell, such as text or a number, date, or time.) To distinguish a formula from data, every formula begins with an equal (=) symbol.

Operators

Operators are used to specify the type of calculation to perform, such as addition or multiplication. Operators can be divided into four categories: arithmetic, comparison, text concatenation, and reference.

- ◆ **Arithmetic operators.** Used to perform mathematical calculations, producing a numerical result.
- ◆ **Comparison operators.** Used to perform logical comparisons between two values, resulting in either `True` or `False`.
- ◆ **Text concatenation operator.** Used to combine two text values, producing a single text string.
- ◆ **Reference operators.** Used to specify cell ranges.

See **Tables 10.3–10.6** for lists of supported operators.

$$\begin{array}{c}
 \text{Cell reference} \\
 | \\
 =A3+18 \\
 \begin{array}{cc}
 | & | \\
 \text{Operator} & \text{Constant}
 \end{array}
 \end{array}$$

Figure 10.3 In this simple formula, 18 is added to the data in cell A3. As is the case with all formulas, the result is displayed in the cell containing the formula.

Table 10.3

Arithmetic Operators		
OPERATOR	DESCRIPTION	EXAMPLE
+	Addition	A3+5
-	Subtraction	18-B7
-	Negation	-17
*	Multiplication	A6*B6
/	Division	G4/3
%	Percent	35%
^	Exponentiation (raise to a power)	A4^2

Table 10.4

Comparison Operators		
OPERATOR	DESCRIPTION	EXAMPLE
=	Equal	A3=B5
>	Greater than	D2>12
<	Less than	E3<E4
>=	Greater than or equal to	A6>=15
<=	Less than or equal to	G4<=3
<>	Not equal to	B7<>5

Table 10.5

Text Concatenation Operator		
OPERATOR	DESCRIPTION	EXAMPLE
&	Concatenation	"Phone: "&B5

Table 10.6

Reference Operators		
OPERATOR	DESCRIPTION	EXAMPLE
:	Range	A3:A8 (all cells from A3 to A8)
,	Union	D2,F2:F5 (cells D2 and F2:F5)
[space]	Intersection	C4:D7 D6:D8 (cells D6 and D7)

Table 10.7

Operator Precedence	
OPERATOR	DESCRIPTION
:	Colon (range)
,	Comma (union)
[space]	Space (intersection)
-	Negation
%	Percent
^	Exponentiation
*, /	Multiplication and division
+, -	Addition and subtraction
&	Concatenation
=, <>, <=, >=	Comparison operators

Precedence

When calculating the result of a formula, Excel evaluates the elements from left to right. However, this holds true only when all operators are of the same importance (called *precedence*). Every operator has a precedence, as shown in **Table 10.7**. The higher in the table an operator appears, the higher its precedence. Thus, when a formula contains operators of differing precedence, the calculations are performed from highest to lowest precedence. Here are some examples:

$$4+2+3 \quad [=9]$$

Explanation: All operators have the same precedence, so the formula is evaluated from left to right.

$$4*2+3 \quad [=11]$$

Explanation: Multiplication has a higher precedence than addition. But because the multiplication occurs first in the formula, the left-to-right order is still followed (8+3).

$$4+2*3 \quad [=10]$$

Explanation: Multiplication has a higher precedence, so $2*3$ is evaluated first (4+6).

Note that you can change the order of evaluation by enclosing terms in parentheses. Such items are always evaluated first. When multiple sets of parentheses are used, items in the innermost ones are evaluated first.

$$4*(2+3) \quad [=20]$$

Explanation: Because parentheses surround the last two terms, they are evaluated first (resulting in 5). Without the parentheses, the formula would have been evaluated in left-to-right order: $4*2$ (or 8), plus 3, for a result of 11.

Relative, absolute, and mixed

Cell references in formulas can be relative, absolute, or mixed. When you enter a reference by typing an address (such as entering $= (B2+C2+D2)/3$ in cell E2), the references to cells B2, C2, and D2 are *relative* to the location of the formula cell (E2). If the formula is moved or copied to another cell, Excel adjusts the cell references to point to the correct cells. For example, copying the formula to cells E3:E7 results in the correct formula in each new cell (**Figure 10.4**).

You use an *absolute reference* (preceding both the column and row with dollar signs) for a cell address that must not change when copied or moved. For example, in a business mileage worksheet (**Figure 10.5**), you could create a formula to calculate Mileage Amount: the trip's total mileage multiplied by a fixed mileage rate (found in cell I2). The initial formula in row 2 would be $=F2*\$I\2 and then repeated in every cell in column G (for example, $=F3*\$I\2). Unlike relative references, absolute references never change, no matter where on the worksheet the formula is copied or moved.

Finally, Excel also supports *mixed references* in which the column or the row is absolute and the other is relative, such as $\$A1$ (column A is absolute, row 1 is relative) and $A\$1$ (column A is relative, row 1 is absolute).

✓ Tip

- When a formula is copied or moved (**Figure 10.6**), the cell references change as shown in **Table 10.8**:
 - ▲ Relative references change to match the formula's new location, relative to the original location. This also applies to the relative part of a mixed reference.
 - ▲ Absolute references do not change. The absolute portion of a mixed reference also remains unchanged.

Formula copied to E3

	A	B	C	D	E
1	Student	Test 1	Test 2	Test 3	Average
2	Michelle	15	14	16	15.00
3	Thomas	18	16	19	17.67
4	Adrian	14	9	11	11.33
5	Anthony	17	14	18	16.33
6	Jonas	20	20	18	19.33
7	Heidi	13	15	16	14.67

Figure 10.4 When the formula $= (B2+C2+D2)/3$ in E2 is copied to cells E3:E7, the relative cell references in the formula automatically adjust to refer to the correct cells.

F	G	H	I
Total Mileage	Mileage Amount		Mileage Rate
10	4.45		0.445
10	4.45		
10	4.45		

Figure 10.5 The formula in column G uses an absolute reference to the fixed mileage rate in cell I2.

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

Figure 10.6 If a formula in C1 is copied or moved to cell D3, it changes as described in Table 10.8.

Table 10.8

Result of Copying or Moving a Formula		
FORMULA (C1)	COPIED/MOVED (D3)	REFERENCE TYPE
$=A1$	$=B3$	Relative
$=\$A\1	$=\$A\1	Absolute
$=\$A1$	$=\$A3$	Mixed (absolute column)
$=A\$1$	$=B\$1$	Mixed (absolute row)



Figure 10.7 The Function Library group organizes Excel functions by category.

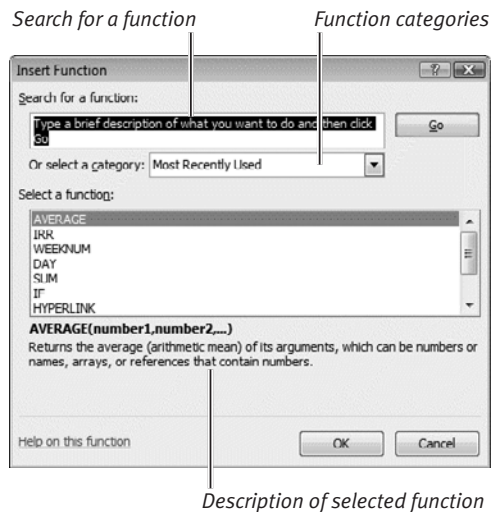


Figure 10.8 Select a function, and then click OK.

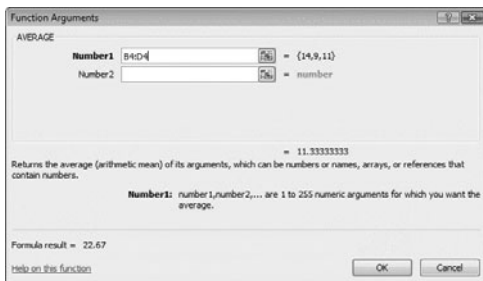


Figure 10.9 You can enter arguments by typing, clicking a cell, or drag-selecting a range.

✓ Tip

- You can also open the Insert Function dialog box by clicking the *fx* icon in the formula bar or by pressing **(Shift)F3**.

Functions

Functions are formula helpers—built-in computational routines that you can include in formulas to simplify the creation of complex and special-purpose calculations. For instance, rather than laboriously totaling a string of cells with the formula `=A1+A2+A3+A4+A5`, you can use the SUM function to add the entire range: `=SUM(A1:A5)`.

All but a few functions require *arguments*, the data on which the function operates. Arguments are enclosed in parentheses and—if there are multiple arguments—separated by commas. The argument to the SUM function above is the range A1:A5. In addition to operating on a single range, SUM can be used to total individual cells and constants, as seen in this formula:

```
=SUM(A1:A5, B7, 23)
```

In this example, the total of cells A1, A2, A3, A4, A5, B7, and 23 is calculated.

When the text insertion mark is at the desired spot in a formula you're creating, you can insert a function in these ways:

- ◆ Functions for which you know the spelling and syntax can be typed directly into the formula.
- ◆ On the Formulas tab, you can choose a function by clicking an icon in the Function Library group (**Figure 10.7**).
- ◆ For guidance in selecting a function, click Insert Function in the Function Library group (**Figure 10.8**), select a function and then click OK.

In the latter two function-insertion methods, the Function Arguments dialog box appears (**Figure 10.9**). Using the guidance provided, enter the argument(s) and click OK to insert the function into your formula.

Creating Formulas

Formulas can be created from any combination of cell contents, constants, and functions. Many common formulas, such as sums or averages of a column or row, can quickly be created using the AutoSum tool.

To create a formula without functions:

1. Select the cell that will contain the formula and type an equal sign (=).
2. Construct the formula by typing constants, cell references, and operators (**Figure 10.10**). Press **Enter** or click the ✓ in the formula bar to complete the formula.

The formula is replaced in the cell by the calculated result (**Figure 10.11**).

To create a formula with functions:

1. Select the cell that will contain the formula and type an equal sign (=).
2. Insert constants and cell references as needed. To insert a function at the text insertion mark, *do one of the following*:
 - ▲ Type the function name, a left parenthesis, the argument(s), and a right parenthesis.
 - ▲ Choose a function from the Function Library group (see **Figure 10.7**). In the Function Arguments dialog box (see **Figure 10.9**), enter the argument(s) and click OK.
 - ▲ Click the Insert Function icon in the Function Library group or on the formula bar. In the Insert Function dialog box (see **Figure 10.8**), select a function and click OK. In the Function Arguments dialog box (see **Figure 10.9**), enter the argument(s) and click OK.
3. Press **Enter** or click the ✓ in the formula bar to complete the formula.

The formula is replaced in the cell by the calculated result.

	A	B	C	D	E
1		Test 1	Test 2	Test 3	Total
2	Michelle	12	14	16	=B2+C2+D2

Referenced cell

Figure 10.10 The formula in E2 totals Michelle's three test scores. As you select cells or type their addresses, Excel displays handles around each referenced cell.

	A	B	C	D	E
1		Test 1	Test 2	Test 3	Total
2	Michelle	12	14	16	42.00

Figure 10.11 When you complete a formula, the result is displayed in the cell. Note that the formula is shown in the formula bar.

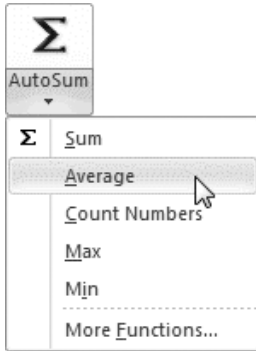


Figure 10.12 Choose a function from the drop-down menu.

H	I	J	K	L	M
	Races	Wins	Places	Shows	
	11	4	0	0	M(12:K2)
	18	4	1	1	1R x 3C
	13	3	2	2	

Figure 10.13 To specify a range for this SUM function, type =SUM(and drag-select the range to be totaled. Type the closing parenthesis to complete the formula.

Formula in F2

=End_Mileage-Start_Mileage			
C	D	E	F
Destination	Start Mileage	End Mileage	Total Mileage
Post Office	3585	3595	10

Figure 10.14 Columns D and E have been named Start_Mileage and End_Mileage. To calculate total mileage for any cell in column F, the names can be substituted for the two cell references.

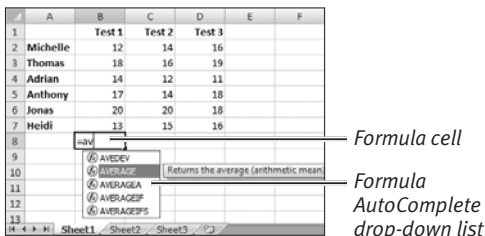


Figure 10.15 Double-click a function name to insert it into the formula.

To create an AutoSum formula:

1. Select the cell at the bottom of a column or end of a row that will contain the formula. The cells that will serve as the argument to the AutoSum function must be a contiguous string within a single column or row, such as B2:B23 or H7:R7.
2. On the Formulas tab, click the AutoSum icon in the Function Library group (Figure 10.12). Choose a function from the drop-down menu or choose More Functions to pick from all Excel functions.
3. Excel highlights the range it thinks you want to use as the argument to the function. Adjust the range, if necessary.
4. Press (Enter) to complete the formula.

✓ Tips

- When you create a formula, a cell reference can be typed or added by clicking the cell you want to reference. You can type or drag-select a range (Figure 10.13) as an argument to a function.
- Typed cell references can be entered in uppercase or lowercase.
- As explained in Chapter 8, if you've named cells or ranges, you can substitute the names for the addresses and ranges in formulas (Figure 10.14).
- If required, a formula can contain multiple functions, as well as functions within functions (called *nested functions*).
- If you can type the first few letters of a function's name when creating a formula, you can use Formula AutoComplete to insert the function (Figure 10.15). Double-click the function name in the drop-down list.
- Functions do *not* ignore empty cells within the argument range(s).

Editing Formulas

You can edit existing formulas to correct errors and to change cell or range references. Many of the techniques described below are also applicable to editing data.

To edit a formula:

1. Select the cell that contains the formula you want to edit.
2. You can edit in the cell or the formula bar, whichever is most convenient. *Do one of the following:*
 - ▲ Double-click the cell.
 - ▲ Click in the formula bar to set the text insertion mark.
3. *Do any of the following:*
 - ▲ Use normal text-editing techniques to add, delete, or change the cell contents.
 - ▲ To clear the cell, drag-select its contents and press **[Backspace]**, or select the cell and press **[Del]** or **[Delete]**.
 - ▲ To change a cell reference from relative, absolute, or mixed to another reference type, select the address within the formula and repeatedly press **[F4]**.
 - ▲ To replace a function, select its name in the formula and begin typing the new function's name. Select the desired function from the Formula AutoComplete list by double-clicking its name (see Figure 10.15). You can also replace a selected function name by choosing a new function from the Function Library group (**Figure 10.16**).
4. Press **[Enter]** to complete the formula.

✓ Tip

- To make an entry in a cell in multiple worksheets, **[Ctrl]**-select the sheet names in the Sheet tab bar, select the cell, and then enter the data or formula.

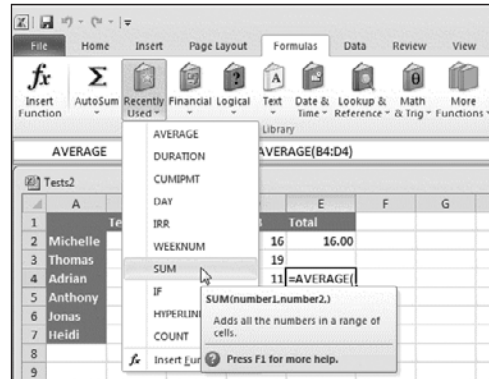


Figure 10.16 Functions can be chosen from the Function Library group's icons. If you regularly use a function, you can often choose it from the Recently Used icon's drop-down menu.

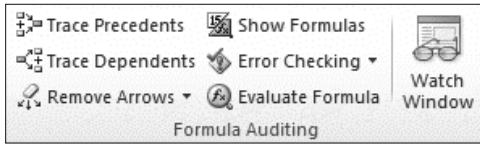


Figure 10.17 Troubleshooting tools are available in the Formula Auditing group of the Formulas tab.

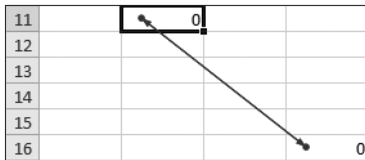


Figure 10.18 This arrow connects two cells that reference each other. The formula in B11 is =D16; the formula in D16 is =B11+8.

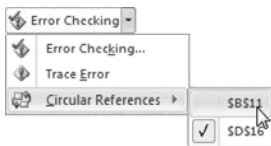


Figure 10.19 You can go directly to a circular reference cell.

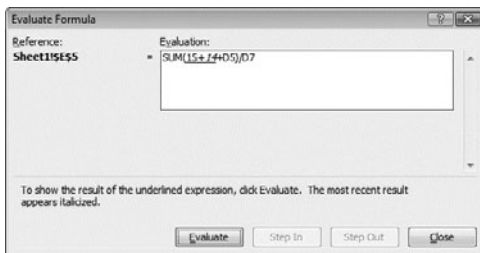


Figure 10.20 Click the Evaluate button to replace the underlined formula element with its data. Click Close when you're finished.

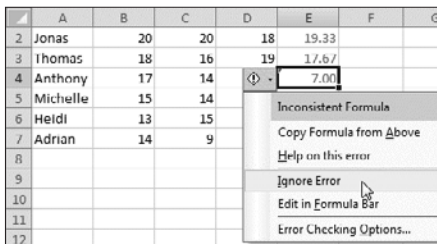


Figure 10.21 Click the icon and choose an option.

Troubleshooting Tips

Following are some techniques for finding and correcting errors in formulas. Start by switching to the Formulas tab to make the icons in the Formula Auditing group (**Figure 10.17**) accessible:

- ◆ **Formulas replaced by data.** To find cells in which you've accidentally replaced a formula with data, click Show Formulas. Any cell containing a formula will now display the formula, rather than the result. Click Show Formulas again to restore the worksheet to its normal state.
- ◆ **Circular references.** If the formulas in two cells rely on each other, Excel cannot correctly perform the calculations. This is known as a *circular reference* and is denoted on the worksheet by an arrow connecting the two cells (**Figure 10.18**). You can also find circular references by clicking the Error Checking icon and choosing any cell listed in the Circular References submenu, as shown in **Figure 10.19**. In a circular reference, only one of the two formulas can refer to the other cell.
- ◆ **Incorrect result.** If a formula displays an unexpected result, select the cell and click Evaluate Formula. By repeatedly clicking the Evaluate button in the Evaluate Formula dialog box (**Figure 10.20**), you can step through the elements in the formula, displaying the result for each step. Evaluating a formula often makes it easy to find incorrect cell references and identify flaws in a formula's logic.
- ◆ **Is it an error?** Excel notifies you immediately if it detects a possible formula error—often by displaying a tiny triangle in the cell's upper-left corner. Select the cell (**Figure 10.21**) and choose a handling option from the drop-down menu.