3. Perform calculations on data

In this chapter

Practice files

For this chapter, use the practice files from the Excel2016SBS\Ch03 folder. For practice file download instructions, see the introduction.

Excel 2016 workbooks give you a handy place to store and organize your data, but you can also do a lot more with your data in Excel. One important task you can perform is to calculate totals for the values in a series of related cells. You can also use Excel to discover other information about the data you select, such as the maximum or minimum value in a group of cells. Regardless of your needs, Excel gives you the ability to find the information you want. And if you make an error, you can find the cause and correct it quickly.

Often, you can't access the information you want without referencing more than one cell, and it's also often true that you'll use the data in the same group of cells for more than one calculation. Excel makes it easy to reference several cells at the same time, so that you can define your calculations quickly.

This chapter guides you through procedures related to streamlining references to groups of data on your worksheets and creating and correcting formulas that summarize an organization's business operations.

Name groups of data

When you work with large amounts of data, it's often useful to identify groups of cells that contain related data. For example, you can create a worksheet in which columns of cells contain data summarizing the number of packages handled during a specific time period and each row represents a region.

		5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
4	Northeast	30,825	53,945	44,668	50,670	51,711	43,141	41,705
5	Atlantic	14,998	7,092	10,650	14,709	14,458	7,714	14,266
6	Southeast	8,603	9,082	13,995	12,447	12,750	10,216	11,189
7	North Central	12,480	12,086	12,147	8,102	7,990	9,143	7,117
8	Midwest	11,639	8,934	7,045	11,869	14,731	14,597	11,205
9	Southwest	14,528	11,238	12,592	8,418	7,389	8,590	12,220
10	Mountain West	10,900	14,362	7,951	12,437	11,534	8,462	10,578
11	Northwest	11,432	7,527	14,753	11,410	7,649	9,730	12,483
12	Central	7,458	8,567	11,424	14,153	13,565	8,690	11,545

Worksheets often contain logical groups of data

Instead of specifying the cells individually every time you want to use the data they contain, you can define those cells as a *range* (also called a *named range*). For example, you can group the hourly packages handled in the Northeast region into a group called *NortheastVolume*. Whenever you want to use the contents of that range in a calculation, you can use the name of the range instead of specifying the range's address.
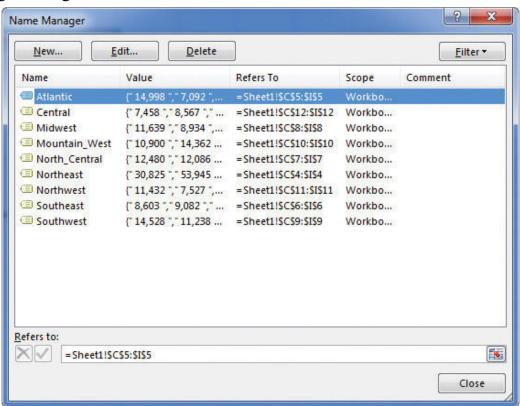

✅ Tip

Yes, you could just name the range *Northeast*, but if you use the range's values in a formula in another worksheet, the more descriptive range name tells you and your colleagues exactly what data is used in the calculation.

If the cells you want to define as a named range have labels in a row or column that's part of the cell group, you can use those labels as the names of the named ranges. For example, if your data appears in worksheet cells B4:I12 and the values in column B are the row labels, you can make each row its own named range.

Select a group of cells to create a named range

If you want to manage the named ranges in your workbook, perhaps to edit a range's settings or delete a range you no longer need, you can do so in the Name Manager dialog box.

Manage named ranges in the Name Manager dialog box

✅ **Tip**

If your workbook contains a lot of named ranges, you can click the Filter button in the Name Manager dialog box and select a criterion to limit the names displayed in the dialog box.

To create a named range

1. Select the cells you want to include in the named range.

2. In the **Name** box, which is next to the formula bar, enter the name for your named range.

Or

1. Select the cells you want to include in the named range.

2. On the **Formulas** tab of the ribbon, in the **Defined Names** group, click **Define Name**.

3. In the **New Name** dialog box, enter a name for the named range.

4. Verify that the named range includes the cells you want.

5. Click **OK**.

To create a series of named ranges from worksheet data with headings

1. Select the cells that contain the headings and data cells you want to include in the named ranges.

2. In the **Defined Names** group, click **Create from Selection**.

3. In the **Create Names from Selection** dialog box, select the check box next to the location of the heading text from which you want to create the range names.

4. Click **OK**.

To edit a named range

1. In the **Defined Names** group, click **Name Manager**.

2. Click the named range you want to edit.

3. In the **Refers to** box, change the cells that the named range refers to.

> *Or*
>
> Click **Edit**, edit the named range in the **Edit Range** box, and click **OK**.

4. Click **Close**.

To delete a named range

1. Click **Name Manager**.

2. Click the named range you want to delete.

3. Click **Delete**.

4. Click **Close**.

Create formulas to calculate values

After you add your data to a worksheet and define ranges to simplify data references, you can create a formula, which is an expression that performs calculations on your data. For example, you can calculate the total cost of a customer's shipments, figure the average number of packages for all Wednesdays in the month of January, or find the highest and lowest daily package volumes for a week, month, or year.
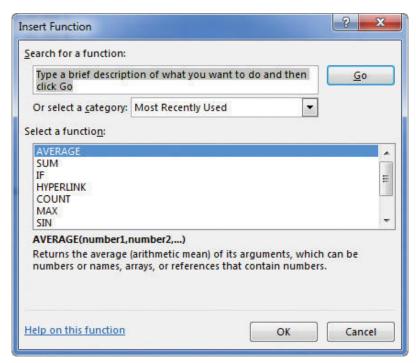
To write an Excel formula, you begin the cell's contents with an equal (=) sign; Excel then knows that the expression following it should be interpreted as a calculation, not text. After the equal sign, you enter the formula. For example, you can find the sum of the numbers in cells C2 and C3 by using the formula *=C2+C3*. After you have entered a formula into a cell, you can revise it by clicking the cell and then editing the formula in the formula bar. For example, you can change the preceding formula to *=C3–C2*, which calculates the difference between the contents of cells C2 and C3.

⚠️ **Important**

> If Excel treats your formula as text, make sure that you haven't accidentally put a space before the equal sign. Remember, the equal sign must be the first character!

Entering the cell references for 15 or 20 cells in a calculation would be tedious, but in Excel you can easily enter complex calculations by using the Insert Function dialog box. The Insert Function dialog box includes a list of functions, or predefined formulas, from which you can choose.

Create formulas with help in the Insert Function dialog box

The following table describes some of the most useful functions in the list.

Function	Description
SUM	Finds the sum of the numbers in the specified cells
AVERAGE	Finds the average of the numbers in the specified cells
COUNT	Finds the number of entries in the specified cells
MAX	Finds the largest value in the specified cells
MIN	Finds the smallest value in the specified cells

Two other functions you might use are the *NOW* and *PMT* functions. The *NOW* function displays the time at which Excel updated the workbook's formulas, so the value will change every time the workbook recalculates. The proper form for this function is *=NOW()*. You could, for example, use the *NOW* function to calculate the elapsed time from when you started a process to the present time.

The *PMT* function is a bit more complex. It calculates payments due on a loan, assuming a constant interest rate and constant payments. To perform its calculations, the *PMT* function requires an interest rate, the number of payments, and the starting balance. The elements to be entered into the function are called *arguments* and must be entered in a certain order. That order is written as

PMT(rate, nper, pv, fv, type). The following table summarizes the arguments in the *PMT* function.

| Argument	Description
rate	The interest rate, to be divided by 12 for a loan with monthly payments, by 4 for quarterly payments, and so on
nper	The total number of payments for the loan
pv	The amount loaned (*pv* is short for *present value*, or principal)
fv	The amount to be left over at the end of the payment cycle (usually left blank, which indicates 0)
type	0 or 1, indicating whether payments are made at the beginning or at the end of the month (usually left blank, which indicates 0, or the end of the month)
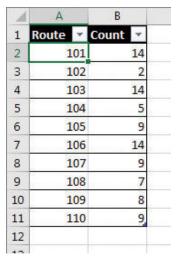
If a company wanted to borrow $2,000,000 at a 6 percent interest rate and pay the loan back over 24 months, you could use the *PMT* function to figure out the monthly payments. In this case, you would write the function *=PMT(6%/12, 24, 2000000)*, which calculates a monthly payment of $88,641.22.

✅ Tip

The 6-percent interest rate is divided by 12 because the loan's interest is compounded monthly.

You can also use the names of any ranges you defined to supply values for a formula. For example, if the named range *NortheastLastDay* refers to cells C4:I4, you can calculate the average of cells C4:I4 with the formula *=AVERAGE(NortheastLastDay)*. With Excel, you can add functions, named ranges, and table references to your formulas more efficiently by using the Formula AutoComplete capability. Just as AutoComplete offers to fill in a cell's text value when Excel recognizes that the value you're typing matches a previous entry, Formula AutoComplete offers to help you fill in a function, named range, or table reference while you create a formula.

As an example, consider a worksheet that contains a two-column Excel table named *Exceptions*. The first column is labeled *Route*; the second is labeled *Count*.

Excel tables track data in a structured format

You refer to a table by typing the table name, followed by the column or row name in brackets. For example, the table reference *Exceptions[Count]* would refer to the *Count* column in the *Exceptions* table.

To create a formula that finds the total number of exceptions by using the *SUM* function, you begin by typing *=SU*. When you enter the letter *S*, Formula AutoComplete lists functions that begin with the letter *S*; when you enter the letter *U*, Excel narrows the list down to the functions that start with the letters *SU*.

Excel displays Formula AutoComplete suggestions to help with formula creation

To add the *SUM* function (followed by an opening parenthesis) to the formula, click *SUM* and then press Tab. To begin adding the table reference, enter the letter *E*. Excel displays a list of available functions, tables, and named ranges that start with the letter *E*. Click *Exceptions*, and press Tab to add the table reference to the formula. Then, because you want to summarize the values in the table's *Count* column, enter an opening bracket, and in the list of available table items, click

Count. To finish creating the formula, enter a closing bracket followed by a closing parenthesis to create the formula *=SUM(Exceptions[Count])*.

If you want to include a series of contiguous cells in a formula, but you haven't defined the cells as a named range, you can click the first cell in the range and drag to the last cell. If the cells aren't contiguous, hold down the Ctrl key and select all of the cells to be included. In both cases, when you release the mouse button, the references of the cells you selected appear in the formula.

	A	B	C	D	E	F	G	H	I	J	K
1											
2		Conveyor									
3		350' track	$14,012.00								
4		Catch bin	$ 895.00								
5		Motor	$ 1,249.00			=sum(C3,C6,C14,C17					
6		Chain drive	$ 1,495.00				SUM(number1, [number2], [number3], [number4], [number5], ...)				
7		Sorting table	$ 675.00								
8		Subtotal		$ 18,326.00							
9											
10		Loading Dock									
11		Concrete	$ 2,169.00								
12		Labor	$ 4,500.00								
13		Posts	$ 300.00								
14		Excavation	$ 2,500.00								
15		Drain	$ 1,800.00								
16		Rails	$ 495.00								
17		Stairs	$ 1,295.00								
18		Subtotal		$ 13,059.00							
19											
20		Build Total		$ 31,385.00							
21		Labor Percentage		#DIV/0!							
22											

A SUM formula that adds individual cells instead of a continuous range

In addition to using the Ctrl key to add cells to a selection, you can expand a selection by using a wide range of keyboard shortcuts.
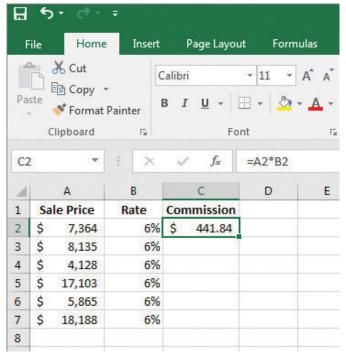
The following table summarizes many of those shortcuts.

Key sequence	Description
Shift+Right Arrow	Extend the selection one cell to the right.
Shift+Left Arrow	Extend the selection one cell to the left.
Shift+Up Arrow	Extend the selection up one cell.
Shift+Down Arrow	Extend the selection down one cell.
Ctrl+Shift+Right Arrow	Extend the selection to the last non-blank cell in the row.
Ctrl+Shift+Left Arrow	Extend the selection to the first non-blank cell in the row.
Ctrl+Shift+Up Arrow	Extend the selection to the first non-blank cell in the column.
Ctrl+Shift+Down Arrow	Extend the selection to the last non-blank cell in the column.
Ctrl+Shift+8 (Ctrl+*)	Select the entire active region.
Shift+Home	Extend the selection to the beginning of the row.
Ctrl+Shift+Home	Extend the selection to the beginning of the worksheet.
Ctrl+Shift+End	Extend the selection to the end of the worksheet.
Shift+PageDown	Extend the selection down one screen.
Shift+PageUp	Extend the selection up one screen.
Alt+;	Select the visible cells in the current selection.

After you create a formula, you can copy it and paste it into another cell. When you do, Excel tries to change the formula so that it works in the new cells. For instance, suppose you have a worksheet where cell D8 contains the formula *=SUM(C2:C6)*. Clicking cell D8, copying the cell's contents, and then pasting the result into cell D16 writes *=SUM(C10:C14)* into cell D16. Excel has reinterpreted the formula so that it fits the surrounding cells! Excel knows it can reinterpret the cells used in the formula because the formula uses a relative reference, or a reference that can change if the formula is copied to another cell. Relative references are written with just the cell row and column (for example, *C14*).
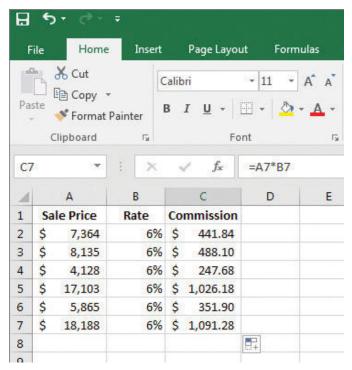
Relative references are useful when you summarize rows of data and want to use the same formula for each row. As an example, suppose you have a worksheet with two columns of data, labeled *Sale Price* and *Rate*, and you want to calculate your sales representative's commission by multiplying the two values in a row. To

calculate the commission for the first sale, you would enter the formula *=A2*B2* in cell C2.

Use formulas to calculate values such as commissions

Selecting cell C2 and dragging the fill handle until it covers cells C2:C7 copies the formula from cell C2 into each of the other cells. Because you created the formula by using relative references, Excel updates each cell's formula to reflect its position relative to the starting cell (in this case, cell C2.) The formula in cell C7, for example, is *=A7*B7*.

Copying formulas to other cells summarizes additional data

You can use a similar technique when you add a formula to an Excel table column. If the sale price and rate data were in an Excel table and you created the formula *=A2*B2* in cell C2, Excel would apply the formula to every other cell in the column. Because you used relative references in the formula, the formulas would change to reflect each cell's distance from the original cell.

Adding a formula to an Excel table cell creates a calculated column

If you want a cell reference to remain constant when you copy the formula that is using it to another cell, you can use an absolute reference. To write a cell reference as an absolute reference, you enter **$** before the row letter and the column number. For example, if you want the formula in cell D16 to show the sum of values in cells C10 through C14 regardless of the cell into which it is pasted, you can write the formula as *=SUM($C$10:$C$14)*.

✅ Tip

> Another way to ensure that your cell references don't change when you copy a formula to another cell is to click the cell that contains the formula, copy the formula's text in the formula bar, press the Esc key to exit cut-and-copy mode, click the cell where you want to paste the formula, and press Ctrl+V. Excel doesn't change the cell references when you copy your formula to another cell in this manner.

One quick way to change a cell reference from relative to absolute is to select the cell reference in the formula bar and then press F4. Pressing F4 cycles a cell reference through the four possible types of references:

- Relative columns and rows (for example, C4)
- Absolute columns and rows (for example, $C$4)
- Relative columns and absolute rows (for example, C$4)
- Absolute columns and relative rows (for example, $C4)

To create a formula by entering it in a cell

1. Click the cell in which you want to create the formula.

2. Enter an equal sign (=).

3. Enter the remainder of the formula, and then press **Enter**.

To create a formula by using the Insert Function dialog box

1. On the **Formulas** tab, in the **Function Library** group, click the **Insert Function** button.

2. Click the function you want to use in your formula.

> *Or*

> Search for the function you want, and then click it.

3. Click **OK**.

4. In the **Function Arguments** dialog box, enter the function's arguments.

5. Click **OK**.

To display the current date and time by using a formula

1. Click the cell in which you want to display the current date and time.

2. Enter **=NOW()** into the cell.

3. Press **Enter**.

To update a *NOW()* formula

      1. Press **F9**.

To calculate a payment by using a formula

      1. Create a formula with the syntax *=PMT(rate, nper, pv, fv, type)*, where:

            • *rate* is the interest rate, to be divided by 12 for a loan with monthly payments, by 4 for quarterly payments, and so on.

            • *nper* is the total number of payments for the loan.

            • *pv* is the amount loaned.

            • *fv* is the amount to be left over at the end of the payment cycle.

            • *type* is 0 or 1, indicating whether payments are made at the beginning or at the end of the month.

      2. Press **Enter**.

To refer to a named range in a formula

      1. Click the cell where you want to create the formula.

      2. Enter = to start the formula.

      3. Enter the name of the named range in the part of the formula where you want to use its values.

      4. Complete the formula.

      5. Press **Enter**.

To refer to an Excel table column in a formula

      1. Click the cell where you want to create the formula.

      2. Enter = to start the formula.

      3. At the point in the formula where you want to include the table's values, enter the name of the table.

            Or

            Use Formula AutoComplete to enter the table name.

      4. Enter an opening bracket ([) followed by the column name.

            Or

            Enter [and use Formula AutoComplete to enter the column name.

      5. Enter]) to close the table reference.

      6. Press **Enter**.

To copy a formula without changing its cell references

      1. Click the cell that contains the formula you want to copy.

      2. Select the formula text in the formula bar.

      3. Press **Ctrl+C**.

      4. Click the cell where you want to paste the formula.

      5. Press **Ctrl+V**.

      6. Press **Enter**.

Operators and precedence

When you create an Excel formula, you use the built-in functions and arithmetic operators that define operations such as addition and multiplication. In Excel, mathematical operators are evaluated in the order listed in the following table.

Operator	Description
-	Negation
%	Percentage
^	Exponentiation
* and /	Multiplication and division
+ and −	Addition and subtraction
&	Concatenation (adding two strings together)

If two operators at the same level, such as + and −, occur in the same equation, Excel evaluates them in left-to-right order. For example, the operations in the formula $= 4 + 8 * 3 - 6$ would be evaluated in this order:

      1. 8 * 3, with a result of 24

      2. 4 + 24, with a result of 28

      3. 28 − 6, with a final result of 22

To move a formula without changing its cell references

      1. Click the cell that contains the formula you want to copy.

      2. Point to the edge of the cell you selected.

      3. Drag the outline to the cell where you want to move the formula.

To copy a formula while changing its cell references

    1. Click the cell that contains the formula you want to copy.

    2. Press **Ctrl+C**.

    3. Click the cell where you want to paste the formula.

    4. Press **Ctrl+V**.

    You can control the order in which Excel evaluates operations by using parentheses. Excel always evaluates operations in parentheses first. For example, if the previous equation were rewritten as = (4 + 8) * 3 – 6, the operations would be evaluated in this order:

    1. (4 + 8), with a result of 12

    2. 12 * 3, with a result of 36

    3. 36 – 6, with a final result of 30

    If you have multiple levels of parentheses, Excel evaluates the expressions within the innermost set of parentheses first and works its way out. As with operations on the same level, such as + and –, expressions in the same parenthetical level are evaluated in left-to-right order.

    For example, the formula = 4 + (3 + 8 * (2 + 5)) – 7 would be evaluated in this order:

    1. (2 + 5), with a result of 7

    2. 7 * 8, with a result of 56

    3. 56 + 3, with a result of 59

    4. 4 + 59, with a result of 63

    5. 63 – 7, with a final result of 56

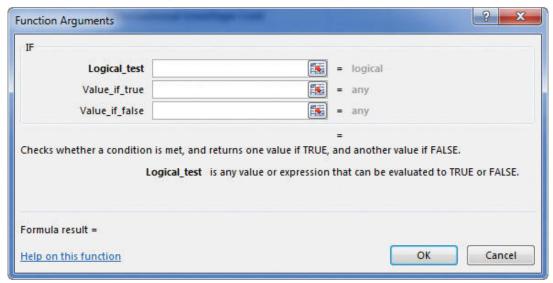**To create relative and absolute cell references**

    1. Enter a cell reference into a formula.

    2. Click within the cell reference.

    3. Enter a **$** in front of a row or column reference you want to make absolute.

        Or

    Press **F4** to advance through the four possible combinations of relative and absolute row and column references.

Summarize data that meets specific conditions

Another use for formulas is to display messages when certain conditions are met. This kind of formula is called a conditional formula; one way to create a conditional formula in Excel is to use the *IF* function. Clicking the Insert Function button next to the formula bar and then choosing the *IF* function displays the Function Arguments dialog box with the fields required to create an *IF* formula.

The Function Arguments dialog box for an IF formula

When you work with an *IF* function, the Function Arguments dialog box has three boxes: *Logical_test*, *Value_if_true*, and *Value_if_false*. The *Logical_test* box holds the condition you want to check.

Now you need to have Excel display messages that indicate whether the condition is met or not. To have Excel print a message from an *IF* function, you enclose the message in quotes in the *Value_if_true* or *Value_if_false* box. In this case, you would type *"High-volume shipper—evaluate for rate decrease"* in the *Value_if_true* box and *"Does not qualify at this time"* in the *Value_if_false* box.

Excel also includes several other conditional functions you can use to summarize your data, as shown in the following table.

Function	Description
AVERAGEIF	Finds the average of values within a cell range that meet a specified criterion
AVERAGEIFS	Finds the average of values within a cell range that meet multiple criteria
COUNT	Counts the number of cells in a range that contain a numerical value
COUNTA	Counts the number of cells in a range that are not empty
COUNTBLANK	Counts the number of cells in a range that are empty
COUNTIF	Counts the number of cells in a range that meet a specified criterion
COUNTIFS	Counts the number of cells in a range that meet multiple criteria
IFERROR	Displays one value if a formula results in an error and another if it doesn't
SUMIF	Finds the sum of values in a range that meet a single criterion
SUMIFS	Finds the sum of values in a range that meet multiple criteria

You can use the *IFERROR* function to display a custom error message, instead of relying on the default Excel error messages to explain what happened. For example, you could use an *IFERROR* formula when looking up a value by using the *VLOOKUP* function. An example of creating this type of formula would be to look up a customer's name, found in the second column of a table named *Customers*, based on the customer identification number entered into cell G8. That formula might look like this: *=IFERROR(VLOOKUP(G8,Customers,2,false),"Customer not found")*. If the function finds a match for the CustomerID in cell G8, it displays the customer's name; if it doesn't find a match, it displays the text *Customer not found*.

✅ **Tip**

The last two arguments in the *VLOOKUP* function tell the formula to look in the *Customers* table's second column and to require an exact match. For more information about the *VLOOKUP*

Just as the *COUNTIF* function counts the number of cells that meet a criterion and the *SUMIF* function finds the total of values in cells that meet a criterion, the *AVERAGEIF* function finds the average of values in cells that meet a criterion. To create a formula that uses the *AVERAGEIF* function, you define the range to be examined for the criterion, the criterion, and, if required, the range from which to draw the values. As an example, consider a worksheet that lists each customer's ID number, name, state, and total monthly shipping bill.

	A	B	C	D
1	CustomerID	CustomerName	State	Total
2	OD100	Contoso	WA	$118,476.00
3	OD101	Fabrikam	WA	$125,511.00
4	OD102	Northwind Traders	OR	$103,228.00
5	OD103	Adventure Works	WA	$ 86,552.00

A list of data that contains customer information

If you want to find the average order of customers from the state of Washington (abbreviated in the worksheet as WA), you can create the formula *=AVERAGEIF(C3:C6, "WA", D3:D6)*.

The *AVERAGEIFS*, *SUMIFS*, and *COUNTIFS* functions extend the capabilities of the *AVERAGEIF*, *SUMIF*, and *COUNTIF* functions to allow for multiple criteria. If you want to find the sum of all orders of at least $100,000 placed by companies in Washington, you can create the formula *=SUMIFS(D3:D6, C3:C6, "=WA", D3:D6, ">=100000")*.

The *AVERAGEIFS* and *SUMIFS* functions start with a data range that contains values that the formula summarizes; you then list the data ranges and the criteria to apply to that range. In generic terms, the syntax runs *=AVERAGEIFS(data_range, criteria_range1, criteria1[,criteria_range2, criteria2...])*. The part of the syntax in brackets (which aren't used when you create the formula) is optional, so an *AVERAGEIFS* or *SUMIFS* formula that contains a single criterion will work. The *COUNTIFS* function, which doesn't perform any calculations, doesn't need a data range—you just provide the criteria ranges and criteria. For example, you could find the number of customers from Washington who were billed at least $100,000 by using the formula *=COUNTIFS(D3:D6, "=WA", E3:E6, ">=100000")*.

To summarize data by using the *IF* function

      1. Click the cell in which you want to enter the formula.

2. Enter a formula with the syntax *=IF(Logical_test, Value_if_true, Value_if_false)* where:

> • *Logical_test* is the logical test to be performed.
>
> • *Value_if_true* is the value the formula returns if the test is true.
>
> • *Value_if_false* is the value the formula returns if the test is false.

To create a formula by using the Insert Function dialog box

1. To the left of the formula bar, click the **Insert Function** button.

2. In the **Insert Function** dialog box, click the function you want to use in your formula.

3. Click **OK**.

4. In the **Function Arguments** dialog box, define the arguments for the function you chose.

5. Click **OK**.

To count cells that contain numbers in a range

1. Click the cell in which you want to enter the formula.

2. Create a formula with the syntax *=COUNT(range)*, where *range* is the cell range in which you want to count cells.

To count cells that are non-blank

1. Click the cell in which you want to enter the formula.

2. Create a formula with the syntax *=COUNTA(range)*, where *range* is the cell range in which you want to count cells.

To count cells that contain a blank value

1. Click the cell in which you want to enter the formula.

2. Create a formula with the syntax *=COUNTBLANK(range)*, where *range* is the cell range in which you want to count cells.

To count cells that meet one condition

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=COUNTIF(range, criteria)* where:

> • *range* is the cell range that might contain the criteria value.
>
> • *criteria* is the logical test used to determine whether to count the cell or not.

To count cells that meet multiple conditions

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=COUNTIFS(criteria_range, criteria,...)* where for each *criteria_range* and *criteria* pair:

> • *criteria_range* is the cell range that might contain the *criteria* value.

> • *criteria* is the logical test used to determine whether to count the cell or not.

To find the sum of data that meets one condition

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=SUMIF(range, criteria, sum_range)* where:

> • *range* is the cell range that might contain the *criteria* value.

> • *criteria* is the logical test used to determine whether to include the cell or not.

> • *sum_range* is the range that contains the values to be included if the *range* cell in the same row meets the criterion.

To find the sum of data that meets multiple conditions

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=SUMIFS(sum_range, criteria_range, criteria,...)* where:

> • *sum_range* is the range that contains the values to be included if all *criteria_range* cells in the same row meet all criteria.

> • *criteria_range* is the cell range that might contain the *criteria* value.

> • *criteria* is the logical test used to determine whether to include the cell or not.

To find the average of data that meets one condition

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=AVERAGEIF(range, criteria, average_range)* where:

> • *range* is the cell range that might contain the *criteria* value.

> • *criteria* is the logical test used to determine whether to include the cell or not.

> • *average_range* is the range that contains the values to be included if the *range* cell in the same row meets the criterion.

To find the average of data that meets multiple conditions

1. Click the cell in which you want to enter the formula.

2. Enter a formula of the form *=AVERAGEIFS(average_range, criteria_range, criteria,...)* where:

> • *average_range* is the range that contains the values to be included if all *criteria_range* cells in the same row meet all criteria.

> • *criteria_range* is the cell range that might contain the *criteria* value.

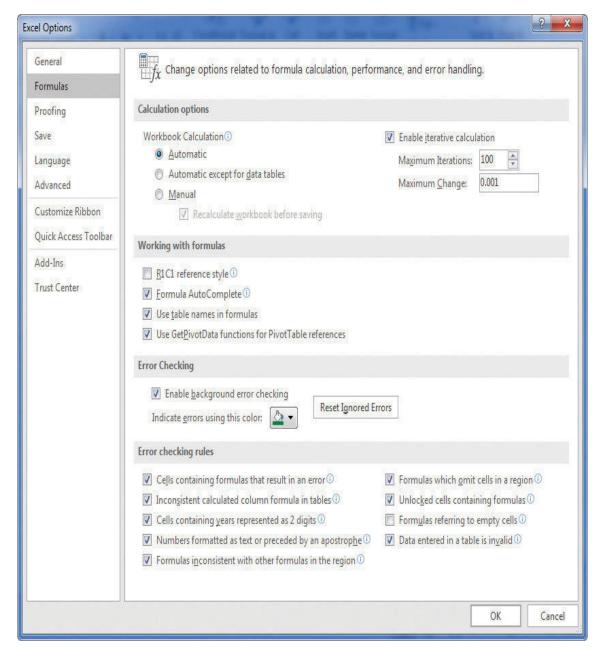> • *criteria* is the logical test used to determine whether to include the cell or not.

To display a custom message if a cell contains an error

1. Click the cell in which you want to enter the formula.

2. Enter a formula with the syntax *=IFERROR(value, value_if_error)* where:

> • *value* is a cell reference or formula.

> • *value_if_error* is the value to be displayed if the *value* argument returns an error.

Set iterative calculation options and enable or disable automatic calculation

Excel formulas use values in other cells to calculate their results. If you create a formula that refers to the cell that contains the formula, you have created a circular reference. Under most circumstances, Excel treats circular references as a mistake for two reasons. First, the vast majority of Excel formulas don't refer to their own cell, so a circular reference is unusual enough to be identified as an error. The second, more serious consideration is that a formula with a circular reference can slow down your workbook. Because Excel repeats, or iterates, the calculation, you need to set limits on how many times the app repeats the operation.

You can control your workbook's calculation options by using the controls on the Formulas page of the Excel Options dialog box.

Set iterative calculation options on the Formulas page of the Excel Options dialog box

The Calculation Options section of the Excel Options dialog box has three available settings:

■ **Automatic** The default setting; recalculates a worksheet whenever a value affecting a formula changes

■ **Automatic except for data tables** Recalculates a worksheet whenever a value changes, but doesn't recalculate data tables

■ **Manual** Requires you to press F9 or, on the Formulas tab, in the Calculation group, click the Calculate Now button to recalculate your worksheet

You can also use options in the Calculation Options section to allow or disallow iterative calculations. If you select the Enable Iterative Calculation check box, Excel repeats calculations for cells that contain formulas with circular references. The default Maximum Iterations value of 100 and Maximum Change of 0.001 are appropriate for all but the most unusual circumstances.

✅ Tip

You can also control when Excel recalculates its formulas by clicking the Formulas tab on the ribbon, clicking the Calculation Options button, and selecting the behavior you want.

To recalculate a workbook

1. Display the workbook you want to recalculate.

2. Press **F9**.

Or

On the **Formulas** tab, in the **Calculation** group, click **Calculate Now**.

To recalculate a worksheet

1. Display the worksheet you want to recalculate.

2. In the **Calculation** group, click the **Calculate Sheet** button.

To set worksheet calculation options

1. Display the worksheet whose calculation options you want to set.

2. In the **Calculation** group, click the **Calculate Options** button.

3. Click the calculation option you want in the list.

To set iterative calculation options

1. Display the Backstage view, and then click **Options**.

2. In the **Excel Options** dialog box, click **Formulas**.

3. In the **Calculation options** section, select or clear the **Enable iterative calculation** check box.

4. In the **Maximum Iterations** box, enter the maximum iterations allowed for a calculation.

5. In the **Maximum Change** box, enter the maximum change allowed for each iteration.

6. Click **OK**.

Use array formulas

Most Excel formulas calculate values to be displayed in a single cell. For example, you could add the formulas *=B1*B4*, *=B1*B5*, and *=B1*B6* to consecutive worksheet cells to calculate shipping insurance costs based on the value of a package's contents.

A worksheet with data to be summarized by an array formula

Rather than add the same formula to multiple cells one cell at a time, you can add a formula to every cell in the target range at the same time by creating an array formula. To create an array formula, you enter the formula's arguments and press Ctrl+Shift+Enter to identify the formula as an array formula. To calculate package insurance rates for values in the cell range B4:B6 and the rate in cell B1, you would select a range of cells with the same shape as the value range and enter the formula *=B1*B4:B6*. In this case, the values are in a three-cell column, so you must select a range of the same shape, such as C4:C6.

A worksheet with an array formula ready to be entered

⚠️ **Important**

If you enter the array formula into a range of the wrong shape, Excel displays duplicate results, incomplete results, or error messages, depending on how the target range differs from the value range.

When you press Ctrl+Shift+Enter, Excel creates an array formula in the selected cells. The formula appears within a pair of braces to indicate that it is an array formula.

⚠️ **Important**

You can't add braces to a formula to make it an array formula—you must press Ctrl+Shift+Enter to create it.

In addition to creating an array formula that combines a single cell's value with an array, you can create array formulas that use two separate arrays. For example, a company might establish a goal to reduce sorting time in each of four distribution centers.

	A	B	C	D
1	Center	Previous Time	Target Percentage	Target Time
2	North	145	85%	
3	South	180	90%	
4	East	195	75%	
5	West	205	70%	
6				

A worksheet with data for an array formula that multiplies two arrays

This worksheet stores the previous sorting times in minutes in cells B2:B5, and the percentage targets in cells C2:C5. The array formula to calculate the targets for each of the four centers is *=B2:B5*C2:C5* which, when entered into cells D2:D5 by pressing Ctrl+Shift+Enter, would appear as *{= B2:B5*C2:C5}*.

To edit an array formula, you must select every cell that contains the array formula, click the formula bar to activate it, edit the formula in the formula bar, and then press Ctrl+Shift+Enter to re-enter the formula as an array formula.

✅ **Tip**

Many operations that used to require an array formula can now be calculated by using functions such as *SUMIFS* and *COUNTIFS*.

To create an array formula

 1. Select the cells into which you want to enter the array formula.

 2. Enter your array formula.

 3. Press **Ctrl+Shift+Enter**.

To edit an array formula

 1. Select the cells that contain the array formula.

 2. Edit your array formula.

 3. Press **Ctrl+Shift+Enter**.

Find and correct errors in calculations

Including calculations in a worksheet gives you valuable answers to questions about your data. As is always true, however, it is possible for errors to creep into your formulas. With Excel, you can find the source of errors in your formulas by identifying the cells used in a specific calculation and describing any errors that have occurred. The process of examining a worksheet for errors is referred to as auditing.

Excel identifies errors in several ways. The first way is to display an error code in the cell holding the formula generating the error.

A worksheet with an error code displayed

When a cell with an erroneous formula is the active cell, an Error button is displayed next to it. If you point to the Error button Excel displays an arrow on the

button's right edge. Clicking the arrow displays a menu with options that provide information about the error and offer to help you fix it.

The following table lists the most common error codes and what they mean.

| Error code	Description
#####	The column isn't wide enough to display the value.
#VALUE!	The formula has the wrong type of argument (such as text in a cell where a numerical value is required).
#NAME?	The formula contains text that Excel doesn't recognize (such as an unknown named range).
#REF!	The formula refers to a cell that doesn't exist (which can happen whenever cells are deleted).
#DIV/0!	The formula attempts to divide by zero.
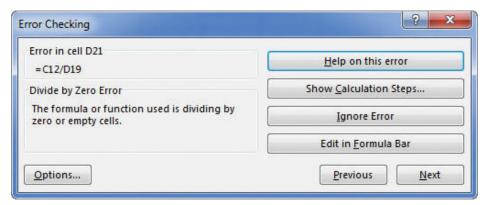
Another technique you can use to find the source of formula errors is to ensure that the appropriate cells are providing values for the formula. You can identify the source of an error by having Excel trace a cell's precedents, which are the cells with values used in the active cell's formula. You can also audit your worksheet by identifying cells with formulas that use a value from a particular cell. Cells that use another cell's value in their calculations are known as dependents, meaning that they depend on the value in the other cell to derive their own value.

9			
10	**Loading Dock**		
11	Concrete	$ 2,169.00	
12	Labor	$ 4,500.00	
13	Posts	$ 300.00	
14	Excavation	$ 2,500.00	
15	Drain	$ 1,800.00	
16	Rails	$ 495.00	
17	Stairs	$ 1,295.00	
18	*Subtotal*		$ 13,059.00
19			
20	**Build Total**		$ 31,385.00
21	**Labor Percentage**		14%
22			

A worksheet with a cell's dependents indicated by tracer arrows

If the cells identified by the tracer arrows aren't the correct cells, you can hide the arrows and correct the formula.

If you prefer to have the elements of a formula error presented as text in a dialog box, you can use the Error Checking dialog box to move through the formula one step at a time, to choose to ignore the error, or to move to the next or the previous error.
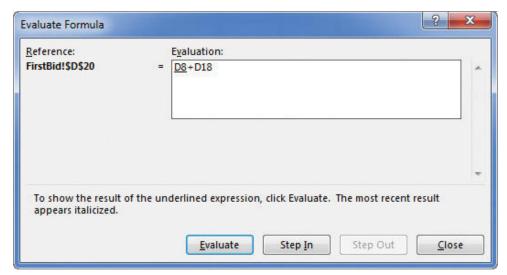

Identify and manage errors by using the Error Checking dialog box

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✅ Tip

You can have the Error Checking tool ignore formulas that don't use every cell in a region (such as a row or column) by modifying this option in the Excel Options dialog box. To do so, on the Formulas tab of the dialog box, if you clear the Formulas Which Omit Cells In A Region check box, you can create formulas that don't add up every value in a row or column (or rectangle) without Excel marking them as an error.

For times when you just want to display the results of each step of a formula and don't need the full power of the Error Checking tool, you can use the Evaluate Formula dialog box to move through each element of the formula. The Evaluate Formula dialog box is much more useful for examining formulas that don't produce an error but aren't generating the result you expect.

Step through formulas by using the Evaluate Formula dialog box

Finally, you can monitor the value in a cell regardless of where in your workbook you are by opening a Watch Window that displays the value in the cell. For example, if one of your formulas uses values from cells in other worksheets or even other workbooks, you can set a watch on the cell that contains the formula and then change the values in the other cells.

As soon as you enter the new value, the Watch Window displays the new result of the formula. When you're done watching the formula, you can delete the watch and hide the Watch Window.

Follow cell values by using the Watch Window

To display information about a formula error

> **1.** Click the cell that contains the error.
>
> **2.** Point to the error indicator next to the cell.
>
> > *Or*
> >
> > Click the error indicator to display more information.

To display arrows identifying formula precedents

1. On the **Formulas** tab, in the **Formula Auditing** group, click the **Trace Precedents** button.

To display arrows identifying cell dependents

1. In the **Formula Auditing** group, click the **Trace Dependents** button.

To remove tracer arrows

1. Do either of the following:

• In the **Formula Auditing** group, click the **Remove Arrows** button (not its arrow).

• Click the **Remove Arrows** arrow and select the arrows you want to remove.

To move through a calculation one step at a time

1. Click the cell that contains the formula you want to evaluate.

2. In the **Formula Auditing** group, click the **Evaluate Formula** button.

3. In the **Evaluate Formula** dialog box, click **Evaluate**.

4. Click **Step In** to move forward by one calculation.

Or

Click **Step Out** to move backward by one calculation.

5. Click **Close**.

To change error display options

1. Display the Backstage view, and then click **Options**.

2. In the **Excel Options** dialog box, click **Formulas**.

3. In the **Error Checking** section, select or clear the **Enable background error checking** check box.

4. Click the **Indicate errors using this color** button and select a color.

5. Click **Reset Ignored Errors** to return Excel to its default error indicators.

6. In the **Error checking rules** section, select or clear the check boxes next to errors you want to indicate or ignore, respectively.

To watch the values in a cell range

1. Click the cell range you want to watch.

2. In the **Formula Auditing** group, click the **Watch Window** button.

3. In the **Watch Window** dialog box, click **Add Watch**.

4. Click **Add**.

To delete a watch

> **1.** Click the **Watch Window** button.
>
> **2.** In the **Watch Window** dialog box, click the watch you want to delete.
>
> **3.** Click **Delete Watch**.

Skills review

In this chapter, you learned how to:

- Name groups of data
- Create formulas to calculate values
- Summarize data that meets specific conditions
- Set iterative calculation options and enable or disable automatic calculation
- Use array formulas
- Find and correct errors in calculations

Practice tasks

The practice files for these tasks are located in the Excel2016SBS\Ch03 folder. You can save the results of the tasks in the same folder.

Name groups of data

Open the CreateNames workbook in Excel, and then perform the following tasks:

> **1.** Create a named range named **Monday** for the V_101 through V_109 values (found in cells **C4:C12**) for that weekday.
>
> **2.** Edit the **Monday** named range to include the V_110 value for that column.
>
> **3.** Select cells **B4:H13** and create named ranges for V_101 through V_110, drawing the names from the row headings.
>
> **4.** Delete the **Monday** named range.

Create formulas to calculate values

Open the BuildFormulas workbook in Excel, and then perform the following tasks:

1. On the **Summary** worksheet, in cell **F9**, create a formula that displays the value from cell **C4**.

2. Edit the formula in cell **F9** so it uses the *SUM* function to find the total of values in cells **C3:C8**.

3. In cell **F10**, create a formula that finds the total expenses for desktop software and server software.

4. Edit the formula in **F10** so the cell references are absolute references.

5. On the **JuneLabor** worksheet, in cell **F13**, create a *SUM* formula that finds the total of values in the **JuneSummary** table's **Labor Expense** column.

Summarize data that meets specific conditions

Open the CreateConditionalFormulas workbook in Excel, and then perform the following tasks:

1. In cell **G3**, create an *IF* formula that tests whether the value in **F3** is greater than or equal to 35,000. If it is, display **Request discount**; if not, display **No discount available**.

2. Copy the formula from cell **G3** to the range **G4:G14**.

3. In cell **I3**, create a formula that finds the average cost of all expenses in cells **F3:F14** where the **Type** column contains the value *Box*.

4. In cell **I6**, create a formula that finds the sum of all expenses in cells **F3:F14** where the **Type** column contains the value *Envelope* and the **Destination** column contains the value *International*.

Set iterative calculation options and enable or disable automatic calculation

Open the SetIterativeOptions workbook in Excel, and then perform the following tasks:

1. On the **Formulas** tab, in the **Calculation** group, click the **Calculation Options** button, and then click **Manual**.

2. In cell **B6**, enter the formula **=B7*B9**, and then press **Enter**.

Note that this result is incorrect because the Gross Savings minus the Savings Incentive should equal the Net Savings value, which it does not.

3. Press **F9** to recalculate the workbook and read the message box indicating you have created a circular reference.

4. Click **OK**.

5. Use options in the **Excel Options** dialog box to enable iterative calculation.

6. Close the **Excel Options** dialog box and recalculate the worksheet.

7. Change the workbook's calculation options to **Automatic**.

Use array formulas

Open the CreateArrayFormulas workbook in Excel, and then perform the following tasks:

1. On the **Fuel** worksheet, select cells **C11:F11**.

2. Enter the array formula **=C3*C9:F9** in the selected cells.

3. Edit the array formula you just created to read **=C3*C10:F10**.

4. Display the **Volume** worksheet.

5. Select cells **D4:D7**.

6. Create the array formula **=B4:B7*C4:C7**.

Find and correct errors in calculations

Open the AuditFormulas workbook in Excel, and then perform the following tasks:

1. Create a watch that displays the value in cell **D20**.

2. Click cell **D8**, and then display the formula's precedents.

3. Remove the tracer arrows from the worksheet.

4. Click cell **A1**, and then use the **Error Checking** dialog box to identify the error in cell **D21**.

5. Show the tracer arrows for the error.

6. Remove the arrows, then edit the formula in cell **D21** so it is **=C12/D20**.

7. Use the **Evaluate Formula** dialog box to evaluate the formula in cell **D21**.

8. Delete the watch you created in step 1.