

# Microsoft Excel Formulas and Functions

(Office 2021 and Microsoft 365)

Paul McFedries



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# Microsoft Excel Formulas and Functions (Office 2021 and Microsoft 365)

Paul McFedries

## **Microsoft Excel Formulas and Functions (Office 2021 and Microsoft 365)**

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# Acknowledgments

Substitute damn every time you're inclined to write very; your editor will delete it and the writing will be just as it should be.

—Mark Twain

I didn't follow Mark Twain's advice in this book (the word *very* appears throughout), but if my writing still appears "just as it should be," then it's because of the keen minds and sharp linguistic eyes of the editors at Pearson Education. Near the front of the book, you'll find a long list of the hard-working professionals whose fingers made it into this particular paper pie. However, there are a few folks I worked with directly, so I'd like to single them out for extra credit. A big, heaping helping of thanks goes out to executive editor Loretta Yates, development and copy editor Rick Kughen, and technical editor Bob Umlas.

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# About the author

**Paul McFedries** is an Excel expert and full-time technical writer. Paul has been authoring computer books since 1991 and has more than 100 books to his credit, which combined have sold more than 4 million copies worldwide. His titles include the Que Publishing books *My Office 2016*, *Windows 10 In Depth* (with coauthor Brian Knittel), and *PCs for Grownups*, as well as the Sams Publishing book *Windows 7 Unleashed*. Please drop by Paul's personal website at [paulmcfedries.com](http://paulmcfedries.com) or follow Paul on Twitter ([twitter.com/paulmcf](https://twitter.com/paulmcf)) and Facebook ([facebook.com/PaulMcFedries](https://facebook.com/PaulMcFedries)).

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# Introduction

The old 80/20 rule for software—that 80 percent of a program’s users use only 20 percent of a program’s features—doesn’t apply to Microsoft Excel. Instead, this program probably operates under what could be called the 95/5 rule: Ninety-five percent of Excel users use a mere 5% of the program’s power. On the other hand, most people *know* that they could be getting more out of Excel if they could only get a leg up on building formulas and using functions. Unfortunately, this side of Excel appears complex and intimidating to the uninitiated, shrouded as it is in the mysteries of mathematics, finance, and impenetrable spreadsheet jargon.

If this sounds like the situation you find yourself in, and if you’re a businessperson who *needs* to use Excel as an everyday part of your job, you’ve come to the right book. In *Microsoft Excel Formulas and Functions (Office 2021 and Microsoft 365)*, I demystify the building of worksheet formulas and present the most useful of Excel’s many functions in an accessible, jargon-free way. This book not only takes you through Excel’s intermediate and advanced formula-building features, but it also tells you *why* these features are useful to you and shows you *how* to use them in everyday situations and real-world models. This book does all this with no-nonsense, step-by-step tutorials and lots of practical, useful examples aimed directly at business users.

Even if you’ve never been able to get Excel to do much beyond storing data and adding a couple of numbers, you’ll find this book to your liking. I show you how to build useful, powerful formulas from the ground up, so no experience with Excel formulas and functions is necessary.

## What’s in the book

---

This book isn’t meant to be read from cover to cover, although you’re certainly free to do just that if the mood strikes you. Instead, most of the chapters are set up as self-contained units that you can dip into at will to extract whatever nuggets of information you need. However, if you’re relatively new to Excel formulas and functions, I suggest starting with Chapter 1, “Building basic formulas,” and Chapter 4, “Understanding functions,” to ensure that you have a thorough grounding in the fundamentals.

The book is divided into four main parts. To give you the big picture before diving in, here’s a summary of what you’ll find in each part:

- **Part I, “Mastering Excel formulas”**—The three chapters in Part I tell you just about everything you need to know about building formulas in Excel. This part

discusses operators, expressions, advanced formula features, and formula-troubleshooting techniques.

- **Part II, “Harnessing the power of functions”**—Functions take your formulas to the next level, and you learn all about them in Part II. After you see how to use functions in your formulas, you examine seven main function categories—text, logical, information, lookup, date, time, and math. In each case, I tell you how to use the functions and give you lots of practical examples that show you how you can use the functions in everyday business situations.
- **Part III, “Building business formulas”**—This part is crammed with business goodies related to performing financial wizardry with Excel. You learn how to implement many standard business formulas in Excel, and you get in-depth looks at Excel’s descriptive and inferential statistical tools, powerful regression-analysis techniques to track trends and make forecasts, and techniques and functions for amortizing loans, analyzing investments, and using discounting for business-case and cash-flow analysis.
- **Part IV, “Building business models”**—The four chapters in Part IV are all business, as they examine various facets of building useful and robust business models. You learn how to analyze data with Excel tables and PivotTables, how to use what-if analysis and Excel’s Goal Seek and scenarios features, and how to use the amazing Solver feature to solve complex problems.

## This book’s special features

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*Microsoft Excel Formulas and Functions (Office 2021 and Microsoft 365)* is designed to give you the information you need without making you wade through ponderous explanations and interminable technical background. To make your life easier, this book includes various features and conventions that help you get the most out of the book and Excel itself:

- **Steps:** Throughout the book, each Excel task is summarized in step-by-step procedures.
- **Things you type:** Whenever I suggest that you type something, what you type appears in a **bold** font.
- **Commands:** I use the following style for Excel menu commands: **File > Open**. This means that you pull down the File menu and select the Open command.
- **Dialog box controls:** The names of dialog box controls and other onscreen elements appear in bold text: Select the **OK** button.

- **Functions:** Excel worksheet functions appear in capital letters: **SUM**. When I list the arguments you can use with a function, they appear in italic to indicate that they're placeholders you replace with actual values; also, optional arguments appear surrounded by square brackets: `CELL(info_type [, reference])`.

This book also uses the following boxes to draw your attention to important (or merely interesting) information.



**Note** The Note box presents asides that offer more information about the topic under discussion. These tidbits provide extra insights that give you a better understanding of the task at hand.



**Tip** The Tip box tells you about Excel methods that are easier, faster, or more efficient than the standard methods.



**Caution** The all-important Caution box tells you about potential accidents waiting to happen. There are always ways to mess things up when you're working with computers. These boxes help you avoid at least some of the pitfalls.

## About the companion content

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To make it easier for you to learn Excel formulas and functions, all the sample content used in the book is available online. To download the sample workbooks, look for the download link on the book's page:

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# Troubleshooting formulas

## In this chapter, you will:

- Decipher the formula error values that Excel displays
- Learn how to fix a few other common formula error types
- Handle formula errors gracefully with the IFERROR function
- Diagnose formula problems using Excel's Formula Error Checker
- Learn how to use Excel's worksheet auditing tools

Despite your best efforts, the odd error might appear in your formulas from time to time. Such errors can be mathematical (for example, dividing by zero), or Excel might simply be incapable of interpreting the formula. In the latter case, problems can be caught while you're entering the formula. For example, if you try to enter a formula that has unbalanced parentheses, Excel doesn't accept the entry, and it displays an error message. Other errors are more insidious. For example, your formula might *appear* to be working—that is, it might return a value—but the result might be incorrect because the data is flawed or because your formula has referenced the wrong cell or range.

Whatever the error and cause, formula woes need to be worked out because you or someone else in your company likely depends on your models to produce accurate results. Don't fall into the trap of thinking that *your* spreadsheets are problem-free. A recent University of Hawaii study found that 50 percent of spreadsheets contained errors that led to "significant miscalculations." And the more complex the model, the greater the chance that errors can creep in. A KPMG study from a few years ago found that a staggering 90 percent of spreadsheets used for tax calculations contained errors.

The good news is that fixing formula flaws need not be drudgery. With a bit of know-how and Excel's top-notch troubleshooting tools, sniffing out and repairing model maladies isn't hard. This chapter tells you everything you need to know.



**Tip** If you try to enter an incorrect formula, Excel won't let you do anything else until you either fix the problem or cancel the operation (which means you lose your formula). If the formula is complex, you might not be able to see the problem right away. Instead of deleting all your work, place an apostrophe (') at the beginning of the formula to convert it to text. This way, you can save your work while you try to figure out the problem.

# Understanding Excel's error values

---

When you enter or edit a formula or change one of the formula's input values, Excel might show an error value as the formula result. Excel has eleven different error values: **#CALC!**, **#DIV/0!**, **#FIELD!**, **#N/A**, **#NAME?**, **#NULL!**, **#NUM!**, **#REF!**, **#SPILL!**, **#UNKNOWN!**, and **#VALUE!**. The next few sections give you a detailed look at these error values and offer suggestions for dealing with them.

## #CALC!

The new **#CALC!** error appears when Excel's calculation engine comes across a formula or expression that it doesn't support. Examples include one of the following:

- An array nested inside another array
- An array that includes one or more range references
- An array that contains no items

## #DIV/0!

The **#DIV/0!** error almost always means that the cell's formula is trying to divide by zero, a mathematical no-no. The cause is usually a reference to a cell that either is blank or contains the value **0**. Check the cell's precedents (the cells that are directly or indirectly referenced in the formula; see "Auditing a worksheet," later in this chapter) to look for possible culprits. You'll also see **#DIV/0!** if you enter an inappropriate argument in some functions. **MOD**, for example, returns **#DIV/0!** if the second argument is **0**.

That Excel treats blank cells as the value **0** can pose problems in a worksheet that requires the user to fill in the data. If your formula requires division by one of the temporarily blank cells, it will show **#DIV/0!** as the result, possibly confusing the user. You can get around this by telling Excel not to perform the calculation if the cell used as the divisor is **0**. This is done with the **IF** worksheet function, which I discuss in detail in Chapter 6, "Working with logical and information functions." (For an even better way to deal with potential formula errors, see "Handling formula errors with **IFERROR**," later in this chapter.) For example, consider the following formula, which uses named cells to calculate gross margin:

```
=GrossProfit / Sales
```

To prevent the **#DIV/0!** error from appearing if the Sales cell is blank (or 0), you'd modify the formula as follows:

```
=IF(Sales = 0, "", GrossProfit / Sales)
```

If the value of the Sales cell is **0**, the formula returns the empty string; otherwise, it performs the calculation.

## #FIELD!

The **#FIELD!** error value tells you that your formula is referencing an invalid linked data type. This can happen in three ways:

- Your formula includes a data-type reference to a field that isn't found in a linked data type. For example, if cell A1 contains a Stocks data type and your formula references **A1.[52-week high]**, you'll get a **#FIELD!** error because the **52-week high** field doesn't exist. In this example, you can solve the problem by removing the dash: **A1.[52 week high]**.
- Your formula includes a data-type reference (for example, **A1.Price** for a Stocks data type) to a cell that doesn't use a linked data type.
- Your formula includes a data-type reference (for example, **A1.Description** for a Stocks data type) to a cell that doesn't have any data for the referenced field.

## #N/A

The **#N/A** error value is short for *not available*, and it means that the formula couldn't return a legitimate result. You usually see **#N/A** when you use an inappropriate argument (or when you omit a required argument) in a function. **HLOOKUP** and **VLOOKUP**, for example (see Chapter 7, "Working with lookup functions"), return **#N/A** if the lookup value is smaller than the first value in the lookup range.

To solve the problem, first check the formula's input cells to see whether any of them are displaying the **#N/A** error. If so, that's why your formula is returning the same error; the problem actually lies in the input cell. When you've found where the error originates, examine the formula's operands to look for inappropriate data types. In particular, check the arguments used in each function to ensure that they make sense for the function and that no required arguments are missing.



**Note** It's common in spreadsheet work to purposely generate an **#N/A!** error to show that a particular cell value isn't currently available. For example, you might be waiting for budget figures from one or more divisions or for the final numbers from month- or year-end. In such a case, you enter **=NA()** into the cell. You fix this "problem" by replacing the **NA** function with the appropriate data when it arrives.

## #NAME?

The **#NAME?** error appears when Excel doesn't recognize a name you used in a formula or when it interprets text within the formula as an undefined name. This means that the **#NAME?** error pops up in a wide variety of circumstances:

- You spelled a range name incorrectly.
- You used a range name that you haven't yet defined.
- You spelled a function name incorrectly.



- You used a function that's part of an uninstalled add-in.
- You used a string value without surrounding it with quotation marks.
- You entered a range reference and accidentally omitted the colon.
- You entered a reference to a range on another worksheet and didn't enclose the sheet name in single quotation marks.



**Tip** When entering function names and defined names, use all lowercase letters. If Excel recognizes a name, it converts the function to all uppercase and the defined name to its original case. If no conversion occurs, you know that you misspelled the name, you haven't defined it yet, or you're using a function from an add-in that isn't loaded.

Remember that you also can use these commands to enter functions and names safely:

- **Formulas > Insert Function** (or press Shift+F3)
- **Formulas > Use In Formula**
- **Formulas > Use In Formula > Paste Names** (or press F3)

These are mostly syntax errors, so fixing them means double-checking your formula and correcting range name or function name misspellings or inserting missing quotation marks or colons. Also, be sure to define any range names you use and to install the appropriate add-in modules for functions you use.

## Avoiding #NAME? errors when deleting range names

If you've used a range name in a formula and then you delete that name, Excel generates the #NAME? error. Wouldn't it be better if Excel just converted the name to its appropriate cell reference in each formula? Possibly, but there is an advantage to Excel's seemingly inconvenient approach. By generating an error, Excel enables you to catch range names that you delete by accident. Because Excel leaves the names in the formula, you can recover by redefining the original range name.

Redefining the original range name becomes problematic if you can't remember the appropriate range coordinates. This is why it's always a good idea to paste a list of range names and their references into each of your workbooks (select **Formulas > Use In Formula > Paste Names > Paste List**).

If you don't need this safety net, you can force Excel to convert deleted range names into their cell references. Here are the steps to follow:

1. Select **File > Options** to display the **Excel Options** dialog box.
2. Select **Advanced**.

3. In the **Lotus Compatibility Settings For** section, use the list to select the worksheet you want to use.
4. Select the **Transition Formula Entry** check box.
5. Select **OK**.

Excel now treats your formula entries the same way Lotus 1-2-3 did way back in days of yore. Specifically, in formulas that use a deleted range name, the name automatically gets converted to its appropriate range reference. As an added bonus, Excel also performs the following automatic conversions:

- If you enter a range reference in a formula, the reference gets converted to a range name (provided that a name exists, of course).
- If you define a name for a range, Excel converts any existing range references into the new name.



**Caution** The treatment of formulas in the Lotus 1-2-3 manner only applies to formulas that you create *after* you select the **Transition Formula Entry** check box.

## #NULL!

Excel displays the **#NULL!** error in a very specific case: when you use the intersection operator (a space) on two ranges that have no cells in common. For example, because the ranges A1:B2 and C3:D4 have no common cells, the following formula returns the **#NULL!** error:

```
=SUM(A1:B2 C3:D4)
```

Check your range coordinates to ensure that they're accurate. Also, check to see if one of the ranges has been moved, causing the two ranges in your formula to no longer intersect.

## #NUM!

The **#NUM!** error means there's a problem with a number in a formula. This almost always means that you entered an invalid argument in a math or trig function. For example, perhaps you entered a negative number as the argument for the **SQRT** or **LOG** function. Check the formula's input cells—particularly those that are used as arguments for mathematical functions—to make sure the values are appropriate.

The **#NUM!** error also appears if you're using iteration (or a function that uses iteration; see Chapter 2, "Creating advanced formulas"), and Excel can't calculate a result. There could be no solution to the problem, or you might need to adjust the iteration parameters.

## #REF!

The **#REF!** error means that a formula contains an invalid cell reference, which is usually caused by one of the following actions:

- You deleted a cell to which the formula refers. You need to add the cell back in or adjust the formula reference.
- You cut a cell and then pasted it into a cell used by the formula. You need to undo the cut and then paste the cell elsewhere. (Note that it's okay to *copy* a cell and paste it onto a cell used by the formula.)
- Your formula references a nonexistent cell address, such as B0. This can happen if you cut or copy a formula that uses relative references and paste it in such a way that the invalid cell address is created. For example, suppose that your formula references cell B1. If you cut or copy the cell containing the formula and paste it one row higher, the reference to B1 becomes invalid because Excel can't move the cell reference up one row.

## #SPILL!

You see the **#SPILL!** error when a dynamic array formula or function that needs to spill data into one or more adjacent cells encounters a non-empty cell in the spill range. (See Chapter 2 to learn more about spill ranges.) You have two ways to handle a **#SPILL!** error:

- Move the formula that needs the spill range to a new location where the spill range is empty.
- Move the existing data out of the spill range.

In both cases, Excel removes the **#SPILL!** error and spills the formula result in the new spill range.

## #UNKNOWN!

If you see the **#UNKNOWN!** error, it means your formula or expression is referencing a data type that isn't supported in your version of Excel. This most often means that the reference is to a data type that was added to a later version of Excel, so the only way to resolve the error is to upgrade to a version of Excel that supports the data type.

## #VALUE!

When Excel generates a **#VALUE!** error, it means you've used an inappropriate argument in a function. This is most often caused by using the wrong data type. For example, you might have entered or referenced a string value instead of a numeric value. Similarly, you might have used a range reference in a function argument that requires a single cell or value. Excel also generates this error if you use a value that's larger or smaller than Excel can handle. In all these cases, you solve the problem by double-checking your function arguments to find and edit the inappropriate arguments.



**Note** Excel can work with values between  $-1E-307$  and  $1E+307$ .

## Fixing other formula errors

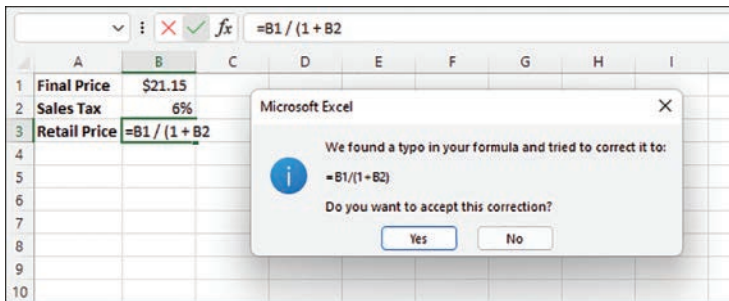
Not all formula errors generate one of Excel's 11 error values. Instead, you might see a warning dialog box from Excel (for example, if you try to enter a function without including a required argument). Or, you might not see any indication that something is wrong. To help you in these situations, the following sections cover some of the most common formula errors.

### Missing or mismatched parentheses

If you miss a parenthesis when typing a formula or place a parenthesis in the wrong location, Excel usually displays a dialog box like the one shown in Figure 3-1 when you attempt to confirm the formula. If the edited formula is what you want, select **Yes** to have Excel enter the corrected formula automatically; if the edited formula is incorrect, select **No** and edit the formula by hand.



**Note** You can work with all the examples in this chapter by downloading Chapter03.xlsx from either of the companion content sites mentioned in the Introduction.



**FIGURE 3-1** If you miss a parenthesis, Excel attempts to fix the problem and displays this dialog box to ask if you want to accept the correction.



**Caution** Excel doesn't always fix missing parentheses correctly. It tends to add the missing parenthesis to the end of the formula, which is often not what you want. Therefore, always check Excel's proposed solution carefully before accepting it.

To help you avoid missing or mismatched parentheses, Excel provides two visual clues in the formula itself when you're editing it:

- The first clue occurs when you type a close parenthesis character—`)`. Excel temporarily bolds both the close parenthesis and its corresponding open parenthesis—`(`. If you type what you think is the last close parenthesis, but Excel doesn't bold the first open parenthesis, your parentheses are unbalanced.
- The second clue occurs when you use the left and right arrow keys to navigate a formula. When you cross over a parenthesis, Excel bolds the other parenthesis in the pair.

## Erroneous formula results

If a formula produces no warnings or error values, the result might still be in error. If the result of a formula is incorrect, here are a few techniques that can help you understand and fix the problem:

- **Calculate complex formulas one term at a time.** In the formula bar, select the expression you want to calculate and then press F9. Excel converts the expression into its value. Make sure that you press the Esc key when you're done to avoid entering the formula with just the calculated values.
- **Evaluate the formula.** You can step through the various parts of a formula, a technique that I describe later in this chapter (see "Evaluating formulas").
- **Break up long or complex formulas.** One of the most problematic aspects of formula troubleshooting is making sense out of long formulas. The previous techniques can help (by enabling you to evaluate parts of the formula), but it's usually best to keep your formulas as short as you can at first. When you get things working properly, you can often combine formulas for a more efficient model.
- **Recalculate all formulas.** A formula might display the wrong result because other formulas on which it depends need to be recalculated. This is particularly true if one or more of those formulas use custom VBA functions. Select Shift+F9 to recalculate all worksheet formulas.
- **Pay attention to operator precedence.** As explained in Chapter 1, "Building basic formulas," Excel's operator precedence means that certain operations are performed before others. An erroneous formula result could, therefore, be caused by Excel's precedence order. To control precedence, use parentheses.
- **Watch out for nonblank "blank" cells.** A cell might appear to be blank but actually contain data or even a formula. For example, some users "clear" a cell by selecting the spacebar, and Excel then treats the cell as nonblank. Similarly, some formulas return an empty string instead of a value. (For example, see the IF function formula earlier in this chapter for avoiding the #DIV/0! error.)

- **Watch unseen values.** In a large model, your formula could be using cells that you can't see because they're offscreen or on another sheet. Excel's **Watch Window** enables you to keep an eye on the current value of one or more cells. To learn about the Watch Window, see "Watching cell values," later in this chapter.

## Fixing circular references

A *circular reference* occurs when a formula refers to its own cell. This can happen in one of two ways:

- **Directly:** The formula explicitly references its own cell. For example, a circular reference would result if the following formula were entered into cell A1:  
 $=A1+A2$
- **Indirectly:** The formula references a cell or function that, in turn, references the formula's cell. For example, suppose that cell A1 contains the following formula:  
 $=A5*10$
- A circular reference would result if cell A5 referred to cell A1, as in this example:  
 $=SUM(A1:D1)$

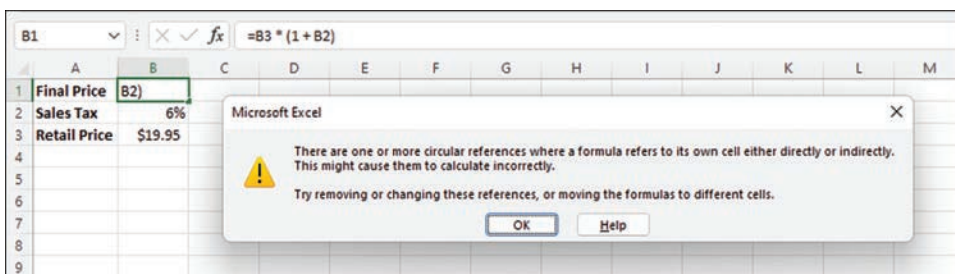
When Excel detects a circular reference, it displays the dialog box shown in Figure 3-2. Here's the formula in cell B3:

$=B1 / (1 + B2)$

Here's the formula in cell B1:

$=B3 * (1 + B2)$

These formulas refer to each other's cells, creating a circular reference.



**FIGURE 3-2** If you attempt to enter a formula that contains a circular reference, Excel displays this dialog box.

When you select **OK**, Excel displays *tracer* arrows that connect the cells involved in the circular reference. (Tracers are discussed in detail later in this chapter; see "Auditing a worksheet.") Knowing which cells are involved enables you to correct the formula in one of them to solve the problem.

## Handling formula errors with IFERROR

---

Earlier, you saw how to use the **IF** function to avoid a **#DIV/0!** error by testing the value of the formula divisor to see if it equals 0. This works fine if you can anticipate the specific type of error the user might make. However, in many instances, you can't know the exact nature of the error in advance. For example, the simple formula `=GrossProfit/Sales` would generate a **#DIV/0!** error if **Sales** equals 0. However, it would generate a **#NAME?** error if the name **GrossProfit** or the name **Sales** no longer exists, or it would generate a **#REF!** error if the cells associated with one or both of **GrossProfit** and **Sales** were deleted.

If you want to handle errors gracefully in your worksheets, it's often best to assume that *any* error can occur. Fortunately, that doesn't mean you have to construct complex tests using deeply nested **IF** functions that check for every error type (**#DIV/0!**, **#N/A**, and so on). Instead, Excel enables you to use a simple test for *any* error by offering the **IFERROR** function:

```
IFERROR(value, value_if_error)
```

<i>value</i>	The expression that might generate an error
<i>value_if_error</i>	The value to return if <i>value</i> returns an error

If the *value* expression doesn't generate an error, **IFERROR** returns the expression result; otherwise, it returns *value\_if\_error* (which might be the null string or an error message). Here's an example:

```
=IFERROR(GrossProfit / Sales, "")
```



**Note** If you want to handle the specific case of the **#N/A** error, use the **IFNA**(*value*, *value\_if\_na*) function. Here, *value* is the expression that you're testing for the **#N/A** error, and *value\_if\_na* is the value to return if *value* returns the **#N/A** error.

## Using the formula error checker

---

If you use Microsoft Word, you're probably familiar with the double blue line that appears under words and phrases that the grammar checker has flagged as being incorrect. The grammar checker operates by using a set of rules that determines correct grammar and syntax. As you type, the grammar checker operates in the background, constantly monitoring your writing. If something you write goes against one of the grammar checker's rules, the wavy line appears to let you know there's a problem.

Excel has a similar feature: the formula error checker. Like the grammar checker, the formula error checker uses a set of rules to determine correctness, and it operates in the background to monitor your formulas. If it detects something amiss, it displays an *error indicator*—a green triangle—in the upper-left corner of the cell containing the formula, as shown in Figure 3-3.

Error indicator

	A	B	C	D	E
1	Final Price	\$21.15	\$26.50	\$31.80	
2	Sales Tax	6%	6%	6%	
3	Retail Price	\$19.95	\$28.19	\$30.00	
4					
5					

**FIGURE 3-3** If Excel's formula error checker detects a problem, it displays a green triangle in the upper-left corner of the formula's cell.

## Choosing an error action

When you select the cell with the formula error, Excel displays a formula error icon beside the cell. If you hover your mouse pointer over the icon, a pop-up message describes the error, as shown in Figure 3-4. The formula error icon drop-down menu contains the following actions:

- **Corrective Action:** This is a command (the name of which depends on the type of error) that Excel believes either will fix the problem or help you troubleshoot the error. For example, in Figure 3-4, Excel is reporting that the formula in cell C3 differs from its neighboring formulas. (In the formula bar, the expression in the parentheses should be **1+C2** instead of **1-C2**.) In this case, the corrective action command in the formula error icon is **Copy Formula From Left**. Or, if Excel can't suggest a solution, it might show the command **Show Calculation Steps**, which runs the Evaluate Formula feature. See "Evaluating formulas," later in this chapter.
- **Help On This Error:** Select this option to get information on the error via the Excel Help system.
- **Ignore Error:** Select this option to leave the formula as is.
- **Edit In Formula Bar:** Select this option to display the formula in **Edit** mode in the formula bar. You can then fix the problem by editing the formula.
- **Error-Checking Options:** Select this option to display the **Formulas** tab of the **Excel Options** dialog box (discussed next).

	A	B	C	D	E	F	G
1	Final Price	\$21.15	\$26.50	\$31.80			
2	Sales Tax	6%	6%	6%			
3	Retail Price	\$19.95	\$28.19	\$30.00			
4							
6							
7							

The formula in this cell differs from the formulas in this area of the spreadsheet.

**FIGURE 3-4** Select the cell containing the error and then move the mouse pointer over the formula error icon to see a description of the error.

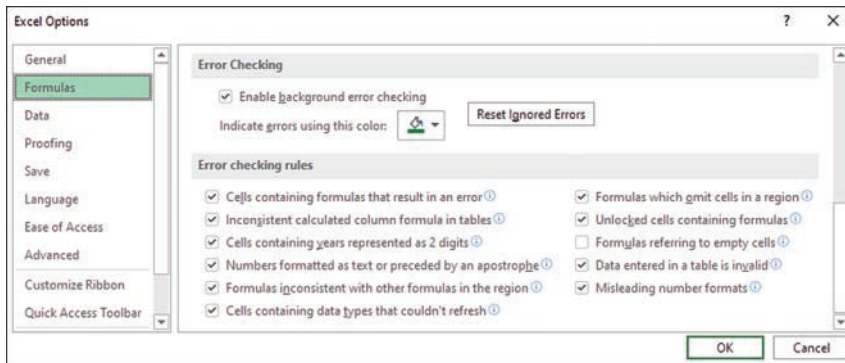


## Setting error checker options

Like Word's grammar checker, Excel's formula error checker has a number of options that control how it works and which errors it flags. To see these options, you have two choices:

- Select **File > Options > Formulas** to open the **Excel Options** dialog box and display the **Formulas** tab.
- Select **Error-Checking Options** in the formula error icon's drop-down menu (as described in the previous section).

Either way, the options appear in the **Error Checking** and **Error Checking Rules** sections in the **Formulas** tab, as shown in Figure 3-5.



**FIGURE 3-5** In the Formulas tab, the Error Checking and Error Checking Rules sections contain the options that govern the workings of the formula error checker.

Here's a rundown of the available options:

- **Enable Background Error Checking:** This check box toggles the formula error checker's background operation on and off. If you turn off the background checking, you can run a check at any time by choosing **Formulas > Error Checking**.
- **Indicate Errors Using This Color:** Use this color palette to select the color of the error indicator.
- **Reset Ignored Errors:** If you've ignored one or more errors, you can redisplay the error indicators by selecting this button.
- **Cells Containing Formulas That Result In An Error:** When this check box is selected, the formula error checker flags formulas that evaluate to **#DIV/0!**, **#NAME?**, or any of the other error values discussed earlier.
- **Inconsistent Calculated Column Formula In Tables:** When this check box is selected, Excel examines the formulas in a table's calculated column and flags any cell that contains a formula with a different structure than the other cells in the column. The formula error icon for this error includes the command **Restore To Calculated Column Formula**, which enables you to update the formula so that it's consistent with the rest of the column.

- Cells Containing Years Represented As 2 Digits:** When this check box is selected, the formula error checker flags formulas that contain date text strings in which the year contains only two digits (a possibly ambiguous situation because the string could refer to a date in either the 1900s or the 2000s). In such a case, the list of options supplied in the formula error icon contains two commands—**Convert XX To 19XX** and **Convert XX To 20XX**—that enable you to convert the two-digit year to a four-digit year.
- Numbers Formatted As Text Or Preceded By An Apostrophe:** When this check box is selected, the formula error checker flags cells that contain a number that is either formatted as text or preceded by an apostrophe. In such a case, the list of options supplied in the formula error icon contains the **Convert To Number** command to convert the text to its numeric equivalent.
- Formulas Inconsistent With Other Formulas In The Region:** When this check box is selected, the formula error checker flags formulas that are structured differently from similar formulas in the surrounding area. In such a case, the list of options supplied in the formula error icon contains a command such as **Copy Formula From Left** to make the formula consistent with the surrounding cells.
- Formulas Which Omit Cells In A Region:** When this check box is selected, the formula error checker flags formulas that omit cells that are adjacent to a range referenced in the formula. For example, suppose that the formula is `=AVERAGE(C4:C21)`, where `C4:C21` is a range of numeric values. If cell C3 also contains a numeric value, the formula error checker flags the formula to alert you to the possibility that you missed including cell C3 in the formula. Figure 3-6 shows this example. In such a case, the list of options supplied in the formula error icon will contain the command **Update Formula To Include Cells** to adjust the formula automatically.

	A	B	C	D	E
1					
2		Sales Rep	2017 Sales	2018 Sales	
3		Nancy Freehafer	\$996,336	\$960,492	
4		Andrew Cencini	\$606,731	\$577,983	
5		Jan Kotas	\$622,781	\$967,580	
6		Mariya Sergienko	\$765,327	\$771,399	
7		Steven Thorpe	\$863,589	\$827,213	
8		Michael Neipper	\$795,518	\$669,394	
9		Robert Zare	\$722,740	\$626,945	
10		Laura Giussani	\$992,059	\$574,472	
11		Anne Hellung-Larsen	\$659,380	\$827,932	
12		Maria Anders	\$509,623	\$569,609	
13		Thomas Hardy	\$987,777	\$558,601	
14		Hanna Moos	\$685,091	\$692,182	
15		Victoria Ashworth	\$540,484	\$693,762	
16		Patricio Simpson	\$650,733	\$823,034	
17		Elizabeth Brown	\$509,863	\$511,569	
18		Ann Devon	\$503,699	\$975,455	
19		Paolo Accorti	\$630,263	\$599,514	
20		Carlos Hernández	\$779,722	\$596,353	
21		Yoshi Latimer	\$592,802	\$652,171	
22		TOTAL	\$13,414,518	\$13,475,660	
23		AVERAGE			
24		The formula in this cell refers to a range that has additional numbers adjacent to it.			
25					

**FIGURE 3-6** The formula error checker can flag formulas that omit cells that are adjacent to a range referenced by the formula. In this case, the formula in C23 should include cell C3.

- **Unlocked Cells Containing Formulas:** When this check box is selected, the formula error checker flags formulas that reside in unlocked cells. This isn't an error so much as a warning that other people could tamper with the formula even after you have protected the sheet. In such a case, the list of options supplied in the formula error icon will contain the command **Lock Cell** to lock the cell and prevent users from changing the formula after you protect the sheet.
- **Formulas Referring To Empty Cells:** When this check box is selected, the formula error checker flags formulas that reference empty cells. In such a case, the list of options supplied in the formula error icon will contain the command **Trace Empty Cell** to enable you to find the empty cell. (At this point, you can either enter data into the cell or adjust the formula so that it doesn't reference the cell.)
- **Data Entered In A Table Is Invalid:** When this check box is selected, the formula error checker flags cells that violate a table's data-validation rules. This can happen if you set up a data-validation rule with only a Warning or Information style, in which case the user can still opt to enter the invalid data. In such cases, the formula error checker will flag the cells that contain invalid data. The formula error icon list includes the **Display Type Information** command, which shows the data-validation rule that the cell data violates.
- **Misleading Number Formats:** When this check box is selected, the formula error checker flags cells that have a numeric, date, or time format that Excel deems incompatible with the formula result. For example, Excel displays this error if a formula applies a mathematical operation to a currency value, but the formula's cell is formatted as a date or time. The formula error icon list includes the **Update Format** command, which changes the cell data format to fit the formula result.

## Auditing a worksheet

---

As you've seen, some formula errors result from referencing other cells that contain errors or inappropriate values. The first step in troubleshooting these formula problems is to determine which cell (or group of cells) is causing an error. This is straightforward if the formula references only a single cell, but it gets progressively more difficult as the number of references increases. (Another complicating factor is the use of range names because it won't be obvious which range each name is referencing.)

To determine which cells are wreaking havoc on your formulas, you can use Excel's auditing features to visualize and trace a formula's input values and error sources.

## Understanding auditing

Excel's formula-auditing features operate by creating *tracers*—arrows that literally point out the cells involved in a formula. You can use tracers to find three kinds of cells:

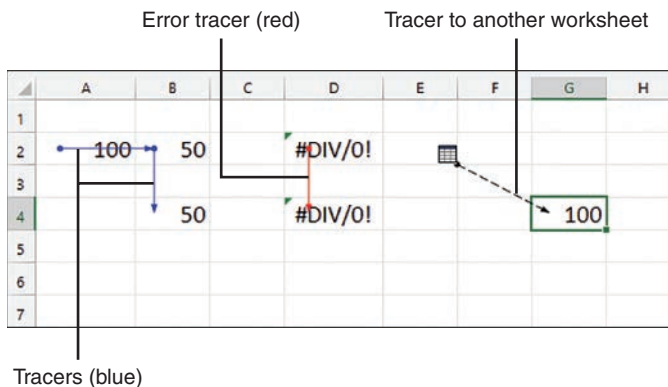
- **Precedents:** These are cells that are directly or indirectly referenced in a formula. For example, suppose that cell B4 contains the formula `=B2`; then B2 is a direct precedent of B4. Now suppose

that cell B2 contains the formula  $=A2/2$ ; this makes A2 a direct precedent of B2, but it's also an *indirect* precedent of cell B4.

- **Dependents:** These are cells that are directly or indirectly referenced by a formula in another cell. In the preceding example, cell B2 is a direct dependent of A2, and B4 is an indirect dependent of A2.
- **Errors:** These are cells that contain an error value and are directly or indirectly referenced in a formula (and therefore cause the same error to appear in the formula).

Figure 3-7 shows a worksheet with three examples of tracer arrows:

- Cell B4 contains the formula  $=B2$ , and B2 contains  $=A2/2$ . The arrows (they're blue onscreen) point out the precedents (direct and indirect) of B4.
- Cell D4 contains the formula  $=D2$ , and D2 contains  $=D1/0$ . The latter produces the **#DIV/0!** error. Therefore, the same error appears in cell D4. The arrow (it's red onscreen) is pointing out the source of the error.
- Cell G4 contains the formula  $=\text{Sheet5!A1}$ . Excel displays the dashed arrow with the worksheet icon whenever the precedent or dependent exists on a different worksheet.



**FIGURE 3-7** This worksheet demonstrates the three types of tracer arrows.

## Tracing cell precedents

To trace cell precedents, follow these steps:

1. Select the cell that contains the formula whose precedents you want to trace.
2. Select **Formulas > Trace Precedents**. Excel adds a tracer arrow to each direct precedent.
3. Keep repeating step 2 to see more levels of precedents.



**Tip** You also can trace precedents by pressing Ctrl+], or by double-clicking the cell, provided that you turn off in-cell editing. You do this by choosing **File > Options > Advanced** and then deselecting the **Allow Editing Directly In Cells** check box. Now when you double-click a cell, Excel selects the formula's precedents.

## Tracing cell dependents

Here are the steps to follow to trace cell dependents:

1. Select the cell whose dependents you want to trace.
2. Select **Formulas > Trace Dependents**. Excel adds a tracer arrow to each direct dependent.
3. Keep repeating step 2 to see more levels of dependents.



**Tip** You also can trace dependents by pressing Ctrl+[.

## Tracing cell errors

To trace cell errors, follow these steps:

1. Select the cell that contains the error you want to trace.
2. Select **Formulas > Error Checking > Trace Error**. Excel adds a tracer arrow to each cell that produced the error.

## Removing tracer arrows

To remove the tracer arrows, you have three choices:

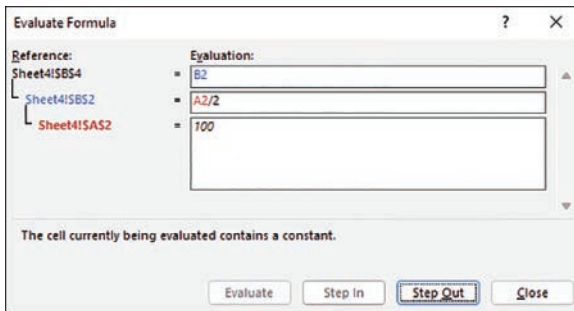
- To remove all the tracer arrows, select **Formulas > Remove Arrows**.
- To remove precedent arrows one level at a time, select **Formulas**, open the **Remove Arrows** drop-down menu, and select **Remove Precedent Arrows**.
- To remove dependent arrows one level at a time, select **Formulas**, open the **Remove Arrows** drop-down menu, and select **Remove Dependent Arrows**.

## Evaluating formulas

Earlier, you learned that you could troubleshoot a wonky formula by evaluating parts of it. You do this by selecting the part of the formula you want to evaluate and then selecting F9. This works fine, but it can be tedious in a long or complex formula, and there's always a danger that you might accidentally confirm a partially evaluated formula and lose your work.

A better solution is to use Excel's Evaluate Formula feature. It does the same thing as the F9 technique, but it's easier and safer. Here's how it works:

1. Select the cell that contains the formula you want to evaluate.
2. Select **Formulas > Evaluate Formula**. Excel displays the **Evaluate Formula** dialog box.
3. The current term in the formula is underlined in the **Evaluation** box. At each step, you select from one or more of the following buttons:
  - **Evaluate:** Display the current value of the underlined term.
  - **Step In:** Display the first dependent of the underlined term. If that dependent also has a dependent, select this button again to see it (see Figure 3-8).
  - **Step Out:** Hide a dependent and evaluate its precedent.
4. Repeat step 3 until you've completed your evaluation.
5. Select **Close**.



**FIGURE 3-8** With the Evaluate Formula feature, you can “step into” the formula to display its dependent cells.

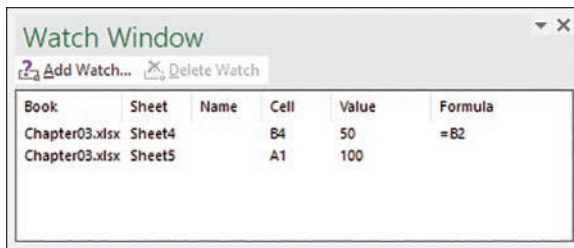
## Watching cell values

In the precedent tracer example shown in Figure 3-7, the formula in cell G4 refers to a cell in another worksheet, which is represented in the trace by a worksheet icon. In other words, you can't see the formula cell and the precedent cell simultaneously. This could also happen if the precedent existed on another workbook or even elsewhere on the same sheet if you're working with a large model.

This is a problem because there's no easy way to determine the current contents or value of the unseen precedent. If you're having a problem, troubleshooting requires that you track down the far-off precedent to see if it might be the culprit. That's bad enough with a single unseen cell, but what if your formula refers to 5 or 10 such cells? And what if those cells are scattered in different worksheets and workbooks?

This level of hassle—not uncommon in the spreadsheet world—was undoubtedly the inspiration behind an elegant solution: the Watch Window. This window enables you to keep tabs on both the value and the formula in any cell in any worksheet in any open workbook. Here’s how you set up a watch:

1. Switch to the workbook that contains the cell or cells you want to watch.
2. Select **Formulas > Watch Window**. Excel displays the **Watch Window**.
3. Select **Add Watch**. Excel displays the **Add Watch** dialog box.
4. Either select the cell you want to watch or type in a reference formula for the cell (for example, =A1). Note that you can select a range to add multiple cells to the Watch Window.
5. Select **Add**. Excel adds the cell or cells to the **Watch Window**, as shown in Figure 3-9.



**FIGURE 3-9** Use the Watch Window to keep an eye on the values and formulas of unseen cells that reside in other worksheets or workbooks.

When you no longer need a watch, you should remove it to avoid cluttering the Watch Window. To remove a watch, select **Formulas > Watch Window** to open the **Watch Window**, select the watch, and then select **Delete Watch**.

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