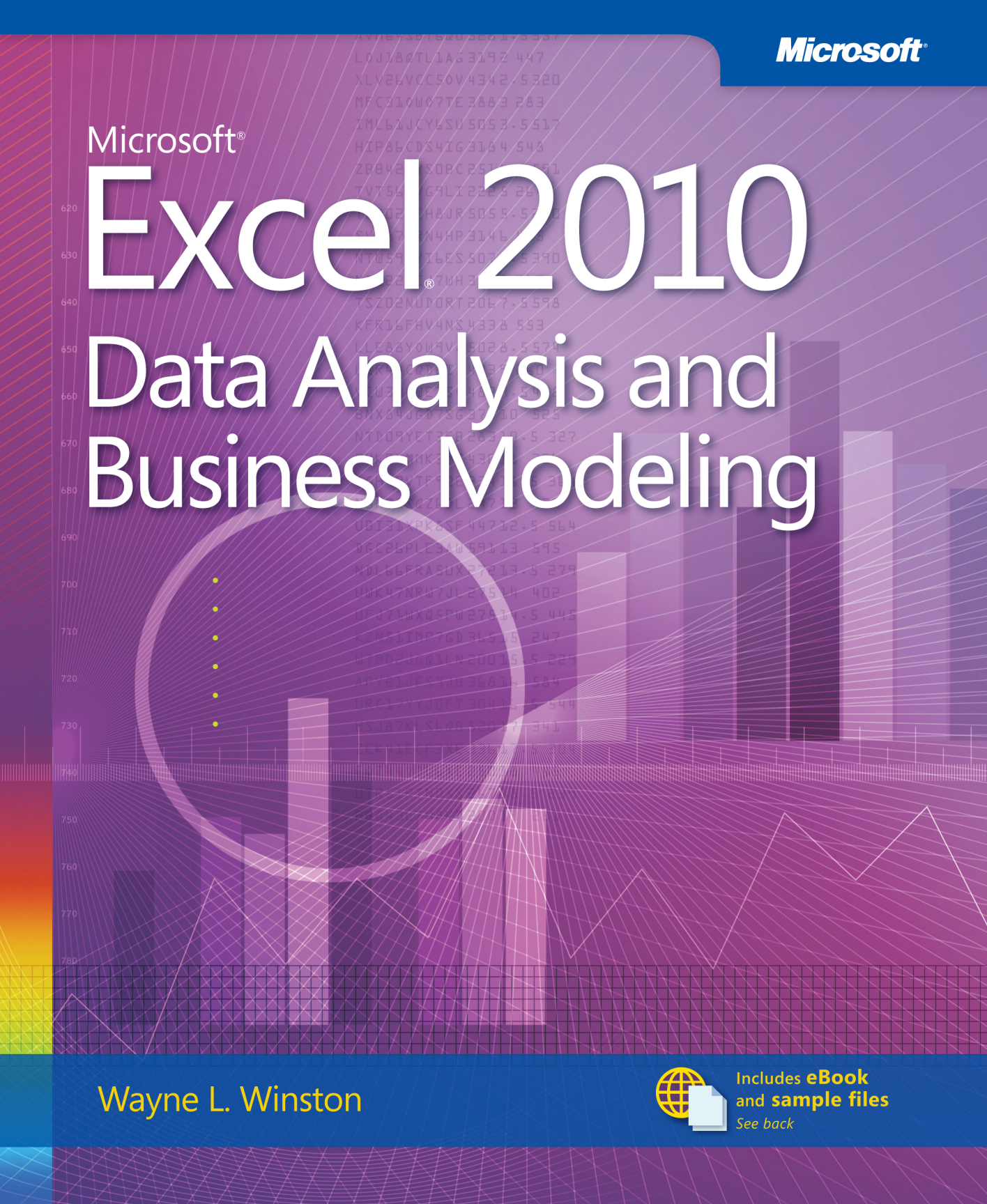
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Microsoft® Excel® 2010: Data Analysis and Business Modeling

Wayne L. Winston

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Introduction

Whether you work for a Fortune 500 corporation, a small company, a government agency, or a not-for-profit organization, if you're reading this introduction the chances are you use Microsoft Excel in your daily work. Your job probably involves summarizing, reporting, and analyzing data. It might also involve building analytic models to help your employer increase profits, reduce costs, or manage operations more efficiently.

Since 1999, I've taught thousands of analysts at organizations such as 3M, Bristol-Myers Squibb, Cisco Systems, Drugstore.com, eBay, Eli Lilly, Ford, General Electric, General Motors, Intel, Microsoft, NCR, Owens Corning, Pfizer, Proctor & Gamble, Tellabs, the U.S. Army, the U.S. Department of Defense, and Verizon how to use Excel more efficiently and productively in their jobs. Students have often told me that the tools and methods I teach in my classes have saved them hours of time each week and provided them with new and improved approaches for analyzing important business problems. Most of these classes used Excel 2003 or Excel 2007. With the added power of Excel 2010, you can be more productive than you ever dreamed! To paraphrase Alicia Silverstone in the movie *Clueless*, Excel 2007 is so five years ago.

I've used the techniques described in this book in my own consulting practice to solve many business problems. For example, I use Excel to help the Dallas Mavericks NBA basketball team evaluate referees, players, and lineups. During the last 15 years I have also taught Excel business modeling and data analysis classes to MBA students at Indiana University's Kelley School of Business. (As proof of my teaching excellence, I have won MBA teaching awards for 25 consecutive years, and have won the school's overall MBA teaching award five times.) I would like to also note that 95 percent of MBA students at Indiana University take my spreadsheet modeling class even though it is an elective.

The book you have in your hands is an attempt to make these successful classes available to everyone. Here is why I think the book will help you learn how to use Excel more effectively:

- The materials have been tested while teaching thousands of analysts working for Fortune 500 corporations and government agencies, including the U.S. Army.
- I've written the book as though I am talking to the reader. I hope this approach transfers the spirit of a successful classroom environment to the written page.
- I teach by example, which makes concepts easier to master. These examples are constructed to have a real-world feel. Many of the examples are based on questions sent to me by employees of Fortune 500 corporations.
- For the most part, I lead you through the approaches I take in Excel to set up and answer a wide range of data analysis and business questions. You can follow along with my explanations by referring to the sample worksheets that accompany each example.

However, I have also included template files for the book's examples on the companion website. If you want to, you can use these templates to work directly with Excel and complete each example on your own.

- For the most part, the chapters are short and organized around a single concept. You should be able to master the content of most chapters with at most two hours of study. By looking at the questions that begin each chapter, you'll gain an idea about the types of problems you'll be able to solve after mastering a chapter's topics.
- In addition to learning about Excel formulas, you will learn some important math in a fairly painless fashion. For example, you'll learn about statistics, forecasting, optimization models, Monte Carlo simulation, inventory modeling, and the mathematics of waiting in line. You will also learn about some recent developments in business thinking, such as real options, customer value, and mathematical pricing models.
- At the end of each chapter, I've provided a group of practice problems (over 600 in total) that you can work through on your own. These problems will help you master the information in each chapter. Answers to all problems are included in files on the book's companion website. Many of these problems are based on actual problems faced by business analysts at Fortune 500 companies.
- Most of all, learning should be fun. If you read this book, you will learn how to predict U.S. presidential elections, how to set football point spreads, how to determine the probability of winning at craps, and how to determine the probability of a specific team winning an NCAA tournament. These examples are interesting and fun, and they also teach you a lot about solving business problems with Excel.
- To follow along with this book, you must have Excel 2010. Previous versions of this book can be used with Excel 2003 or Excel 2007.

What You Should Know Before Reading This Book

To follow the examples in this book you do not need to be an Excel guru. Basically, the two key actions you should know how to do are the following:

- **Enter a formula** You should know that formulas must begin with an equal sign (=). You should also know the basic mathematical operators. For example, you should know that an asterisk (*) is used for multiplication, a forward slash (/) is used for division, and the caret key (^) is used to raise a quantity to a power.
- **Work with cell references** You should know that when you copy a formula that contains a cell reference such as $A$4 (an absolute cell reference, which is created by including the dollar signs), the formula still refers to cell A4 in the cells you copy it to. When you copy a formula that contains a cell reference such as $A4 (a mixed cell address), the column remains fixed, but the row changes. Finally, when you copy a formula that contains a cell reference such as A4 (a relative cell reference), both the row and the column of the cells referenced in the formula change.

How to Use This Book

As you read along with the examples in this book, you can take one of two approaches:

- You can open the template file that corresponds to the example you are studying and complete each step of the example as you read the book. You will be surprised how easy this process is and amazed with how much you learn and retain. This is the approach I use in my corporate classes.
- Instead of working in the template, you can follow my explanations as you look at the final version of each sample file.

Using the Companion Content

This book features a companion website that makes available to you all the sample files you use in the book's examples (both the final Excel workbooks and starting templates you can work with on your own). The workbooks and templates are organized in folders named for each chapter. The answers to all chapter-ending problems in the book are also included with the sample files. Each answer file is named so that you can identify it easily. For example, the file containing the answer to Problem 2 in Chapter 10 is named s10_2.xlsx.

To work through the examples in this book, you need to copy the book's sample files to your computer. These practice files, and other information, can be downloaded from the book's detail page, located at:

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Display the detail page in your Web browser, and follow the instructions for downloading the files.

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I am eternally grateful to Jennifer Skoog and Norm Tonina, who had faith in me and first hired me to teach Excel classes for Microsoft finance. Jennifer in particular was instrumental in helping design the content and style of the classes on which the book is based. Keith Lange of Eli Lilly, Pat Keating and Doug Hoppe of Cisco Systems, and Dennis Fuller of the U.S. Army also helped me refine my thoughts on teaching data analysis and modeling with Excel.

I was blessed to work with John Pierce again, who edited the first edition of the book. Mitch Tulloch did a great job with the technical editing. Thanks also to Steve Sagman for managing the book's production and to proofreader Tom Speeches. Microsoft Press editors Rosemary Caperton and Devon Musgrave helped shepherd the project to completion.

I am grateful to my many students at the organizations where I've taught and at the Kelley School of Business. Many of them have taught me things I did not know about Excel.

Alex Blanton, formerly of Microsoft Press, championed this project at the start and shared my vision of developing a user-friendly text designed for use by business analysts.

Finally, my lovely and talented wife, Vivian, and my wonderful children, Jennifer and Gregory, put up with my long weekend hours at the keyboard.

Chapter 22

The OFFSET Function

Questions answered in this chapter:

- How can I create a reference to a range of cells that is a specified number of rows and columns from a cell or another range of cells?
- How can I perform a lookup operation based on the right-most column in a table range instead of the left-most column?
- I often download software product sales information listed by country. I need to track revenues from Iran as well as costs and units sold, but the data about Iran isn't always in the same location in the worksheet. Can I create a formula that will always pick out Iran's revenues, costs, and units sold?
- Each drug developed by my company goes through three stages of development. I have a list of the cost by month for each drug, and I also know the length in months of each development stage. Can I create formulas that compute for each drug the total cost incurred during each stage of development?
- I run a small video store. In a worksheet, my accountant has listed the name of each movie and the number of copies in stock. Unfortunately, he combined this information in one cell for each movie. How can I extract the number of copies of each movie in stock to a separate cell?
- How does Excel's Evaluate Formula feature work?
- How can I write a formula that always returns the last number in a column?
- How can I set up a range name that automatically includes new data?
- I am charting my company's monthly unit sales. Each month, I download the most recent month's unit sales. I would like my chart to update automatically. Is there an easy way to accomplish this?

The OFFSET function is used to create a reference to a range that is a specified number of rows and columns away from a cell or range of cells. Basically, to create a reference to a range of cells, you first specify a reference cell. You then indicate the number of rows and columns away from the reference cell that you want to create your range. For example, by using the OFFSET function, I can create a reference to a cell range that contains two rows and three columns and begins two columns to the right and one row above the current cell. You can calculate the specified number of rows and columns you move from a reference cell by using other Excel functions.

The syntax of the OFFSET function is *OFFSET(reference,rows moved,columns moved,height,width)*.

- *Reference* is a cell or range of cells from which the offset begins. If you specify a range of cells, the cells must be adjacent to each other.
- *Rows moved* is the number of rows away from the reference cell or range that you want the range reference to start (the upper-left cell in the offset range). A negative number of rows moves you up from the reference; a positive number of rows moves you down. For example, if *reference* equals C5 and *rows moved* equals –1, you move to row 4. If *rows moved* equals +1, you move to row 6. If *rows moved* equals 0, you stay at row 5.
- *Columns moved* is the number of columns away from the reference cell or range that you want the range reference to start. A negative number of columns moves you left from the reference; a positive number of columns moves you right. For example, if *reference* equals C5 and *columns moved* equals –1, you move to column B. If *columns moved* equals +1, you move to column D. If *columns moved* equals 0, you stay at column C.
- *Height* and *width* are optional arguments that give the number of rows and columns in the offset range. If *height* or *width* is omitted, the OFFSET function creates a range for which the value of *height* or *width* equals the height or width of the reference cell or range.

Answers to This Chapter's Questions

How can I create a reference to a range of cells that is a specified number of rows and columns from a cell or another range of cells?

The file Offsetexample.xlsx, shown in Figure 22-1, provides some examples of the OFFSET function in action.

	A	B	C	D	E	F	G	H	I	J	K
1											
2											
3		**Offset examples**									
4											
5											
6		1	2	3	4			1	2	3	4
7		5	6	7	8			5	6	7	8
8		9	10	11	12			9	10	11	12
9											
10	=SUM(OFFSET(B7,-1,1,2,1)	8					=SUM(OFFSET(H6,0,1,3,	39			
11											
12											
13											
14		1	2	3	4						
15		5	6	7	8						
16		9	10	11	12						
17											
18	=SUM(OFFSET(E16,-2,-3,2,	24									
19											

FIGURE 22-1 Using the OFFSET function.

For example, in cell B10, I entered the formula shown in cell A10: *SUM(OFFSET(B7,–1,1,2,1))*. This formula begins in cell B7. It moves one row up and one column to the right, which brings us to cell C6. The formula now selects a range consisting of two rows and one column, which yields the range C6:C7. The SUM function adds the numbers in this range, which yields *2+6=8*. The other two examples shown in Figure 22-1 work the same way. In the following sections, I'll show you how to apply the OFFSET function to some problems that were sent to me by former students working at major U.S. companies.

How can I perform a lookup operation based on the right-most column in a table range instead of the left-most column?

In Figure 22-2 (see the workbook Lefthandlookup.xlsx), I listed the members of the 2002–2003 Dallas Mavericks NBA basketball team and their field goal percentages. If I'm asked to find the player with a specific field goal percentage, I could easily solve that problem by using a VLOOKUP function. But what I really want to do is a "left-hand lookup," which involves finding the field goal percentage for a player by using his name. A VLOOKUP function can't perform a left-hand lookup, but a left-hand lookup is simple if you combine the MATCH and OFFSET functions.

	B	C	D	E
6			Name	FG %age
7	FG%	Player	Walt Williams	0.397
8	45.8%	Dirk Nowitzki		
9	41.8%	Michael Finley		
10	46.3%	Steve Nash		
11	39.5%	Nick Van Exel		
12	53.5%	Raef LaFrentz		
13	60.2%	Eduardo Najera		
14	51.2%	Shawn Bradley		
15	39.7%	Walt Williams		
16	44.4%	Adrian Griffin		
17	48.4%	Avery Johnson		
18	47.6%	Raja Bell		
19	66.7%	Evan Eschmeyer		
20	41.0%	Popeye Jones		
21	40.0%	Mark Strickland		
22	23.5%	Adam Harrington		

FIGURE 22-2 You can do a left-hand lookup by using the MATCH and OFFSET functions.

First, I enter the player's name in cell D7. Then I use a reference cell of B7 (the field goal percentage column header) in the OFFSET function. To find the player's field goal percentage, I need to move down to the row below row 7 where the player's name appears. This is a job for the MATCH function. The MATCH function portion of the formula *OFFSET(B7,MATCH(D7,$C$8:$C$22,0),0)* moves down to the row containing the specified player's name and then moves over 0 columns. Because the reference consists of one cell, omitting the *height* and *width* arguments of the OFFSET function ensures that the range returned by this formula is also one cell. Thus, I pick up the player's field goal percentage.

I often download software product sales information listed by country. I need to track revenues from Iran as well as costs and units sold, but the data about Iran isn't always in the same location in the worksheet. Can I create a formula that will always pick out Iran's revenues, costs, and units sold?

The file Asiansales.xlsx (see Figure 22-3) contains data for units sold, sales revenue, and variable cost for software sold to several countries in Asia and the Middle East. Each month, when you download the monthly financial reports, the location of each country in the worksheet changes, so you need formulas that always return (for a given country) the correct units sold, revenue, and variable cost.

	C	D	E	F
6	Country/Region	Units sold	Revenue	Variable Cost
7	India	541	$ 4,328	$ 1,082
8	China	1000	$ 5,000	$ 2,000
9	Iran	577	$ 2,308	$ 1,731
10	Israel	454	$ 3,632	$ 1,362
11	Japan	141	$ 705	$ 423
12	Taiwan	221	$ 1,105	$ 442
13	Thailand	223	$ 1,115	$ 446
14	Indonesia	524	$ 2,620	$ 1,572
15	Malaysia	328	$ 1,968	$ 656
16	Vietnam	469	$ 2,814	$ 1,407
17	Cambodia	398	$ 1,990	$ 796
18				
19		Units sold	Revenue	Variable Cost
20	Country/Region	1	2	3
21	Iran	577	2308	1731

FIGURE 22-3 You can use the OFFSET function in calculations when you're working with data that isn't always in the same location in a worksheet.

By copying from D21 to E21:F21 the formula *OFFSET($C$6,MATCH ($C21,$C$7:$C$17,0),D20),* you can compute the result you want. This formula sets *reference* equal to cell C6 (which contains the words *Country/Region*). Then it moves over one column (to cell D20) to find units sold and down to the row containing the country listed in C21. In cell E21, the reference to D20 now refers to E20 and becomes a 2, so you move over two columns to the right of column C to find revenue. In cell E21, the reference to D20 now refers to F20 and becomes a 3, so you move three columns to the right of column C to find variable cost.

Each drug developed by my company goes through three stages of development. I have a list of the cost by month for each drug, and I also know how many months each development stage took for each drug. Can I create formulas that compute for each drug the total cost incurred during each stage of development?

The file Offsetcost.xlsx contains the monthly costs incurred to develop five drugs and, for each drug, the number of months required to complete each phase. A subset of the data is shown in Figure 22-4.

	B	C	D	E	F	G	H
1		Dur Phase 1	2	3	9	12	6
2		Dur Phase 2	2	8	5	4	12
3		Dur Phase 3	2	11	4	11	15
4		Phase 1 Cost	110	313	795	1167	615
5		Phase 2 Cost	142	789	465	397	1096
6		Phase 3 Cost	234	876	401	1135	1588
7							
8							
9	Code	Month	Drug 1	Drug 2	Drug 3	Drug 4	Drug 5
10	1	Jan-98	52	135	131	121	69
11	2	Feb-98	58	120	77	60	68
12	3	Mar-98	80	58	66	52	113
13	4	Apr-98	62	56	78	61	146
14	5	May-98	130	126	98	118	94
15	6	Jun-98	104	102	64	117	125
16	7	Jul-98	121	59	115	112	137
17	8	Aug-98	107	123	56	102	77
18	9	Sep-98	80	88	110	85	93
19	10	Oct-98	51	111	72	118	89
20	11	Nov-98	74	124	82	143	66
21	12	Dec-98	76	107	99	78	66
22	13	Jan-99	97	97	129	77	142

FIGURE 22-4 Using the OFFSET function to compute development costs for Phases 1–3.

The goal is to determine for each drug the total cost incurred during each development phase. In cells D4:D6, I compute the total development costs for Phases 1–3 for Drug 1. I compute Phase 1 costs for Drug 1 by using a cell reference of D10, with *rows moved* and *columns moved* equal to 0. Setting *height* equal to the number of months in Phase 1 and *width* equal to 1 captures all Phase 1 costs. I compute Phase 1 costs for Drug 1 in cell D4 with the formula *SUM(OFFSET(D10,0,0,D1,1))*. Next, in cell D5, I compute Phase 2 total costs for Drug 1 by using the formula *SUM(OFFSET(D10,D1,0,D2,1))*. Note that I start with a cell reference of D10 (the first month of costs) and move down the number of rows equal to the length of Phase 1. This brings me to the beginning of Phase 2. Setting *height* equal to the value in cell D2 ensures that I include all Phase 2 costs. Finally, in cell D6, I find the Phase 3 development costs for Drug 1 by using the formula *SUM(OFFSET(D10,D1+D2,0,D3,1))*. In this formula, I start from the first month of sales and move down the number of rows equal to the total time needed for Phases 1 and 2. This brings me to the beginning of Phase 3, where in cell D3, I total the number of rows to capture Phase 3 costs. Then, by copying the formulas in D4:D6 to E4:H6, I can compute total costs for Phases 1–3 for Drugs 2 through 5. For example, for Drug 2, total Phase 1 costs equal $313, total Phase 2 costs equal $789, and total Phase 3 costs equal $876.

I run a small video store. In a worksheet, my accountant has listed the name of each movie and the number of copies in stock. Unfortunately, he combined this information into one cell for each movie. How can I extract the number of copies of each movie in stock to a separate cell?

The file Movies.xlsx, shown in Figure 22-5, contains the name of each movie and the number of copies in stock.

	A	B	C	D	E	F	G	H	I
1	count words	Number	Movie and Number of Copies						
2	2	40	Seabiscuit 40	Seabiscuit	40				
3	4	12	Laura Croft Tombraider 12	Laura	Croft	Tombraider	12		
4	6	36	Raiders of the Lost Ark 36	Raiders	of	the	Lost Ark		36
5	3	5	Annie Hall 5	Annie	Hall	5			
6	2	4	Manhattan 4	Manhattan	4				
7	3	112	Star Wars 112	Star	Wars	112			
8	4	128	How to Deal 128	How	to	Deal	128		
9	4	1	The Matrix Reloaded 1	The	Matrix	Reloaded	1		
10	3	1040	Johnny English 1040	Johnny	English	1040			
11	3	12	Rosemary's Baby 12	Rosemary's	Baby	12			
12	3	1002	High Noon 1002	High	Noon	1002			

FIGURE 22-5 Movie example using the OFFSET function.

I want to extract the number of copies owned of each movie to a separate cell. If the number of copies were listed to the left of a movie's title, this problem would be easy. I could use the FIND function to locate the first space and then use the LEFT function to return all the data to the left of the first space. (See Chapter 6, "Text Functions," for a discussion of how to use the LEFT and FIND functions, as well as other functions you can use to work with text.) Unfortunately, this technique doesn't work when the number of copies is listed to the right of the movie title. For a one-word movie title, for example, the number of copies is to the right of the first space, but for a four-word movie title, the number of copies is to the right of the fourth space.

One way to solve this problem is to click the Data tab on the ribbon and, in the Data Tools group, click Text To Columns to place each word in a title and the number of copies in separate columns. You can use the COUNTA function to count the total number of words in a title, including the number of items as a word, for each movie. You can then use the OFFSET function to locate the number of items.

To begin, insert enough columns to the right of the data to allow each word in the movies' titles and the number of items to be extracted to a separate column. I used six columns (*Raiders of the Lost Ark* requires six columns), as you can see in Figure 22-5. Then I select the cell range C2:C12, and click Text To Columns on the Data tab. I select Delimited in the Convert Text To Columns Wizard and use the space character as the delimiting character. After selecting cell D2 as the destination cell, I have the results shown in columns D through I of Figure 22-5.

Now I count the number of words in each movie's cell (counting the number of items as a word) by copying from A2 to A3:A12 the formula *COUNTA(D2:I2)*. The results are shown in Figure 22-5.

Finally, copying from B2 to B3:B12 the formula *OFFSET(C2,0,A2)*, I can locate the number of copies of each movie in stock. This formula begins at the reference cell containing the movie title and moves over the number of columns equal to the number of "words" in the title cell. Because the reference cell contains only one cell, I can omit the *height* and *width* arguments of the OFFSET function so that the function uses only the cell containing the last "word" (the number of copies) of the title cell.

How does Excel's Evaluate Formula feature work?

If you select any portion of a cell formula and then press F9, Excel displays the value created by that portion of the formula. You must press Esc or you lose the formula. This trick makes debugging and understanding complex formulas easier. Thus, it might be easier to understand what the OFFSET portion of the formula does if you apply this trick to any of the formulas in this chapter. For example, in the file Offsetcost.xlsx, cell E4 generates total Phase 1 cost with the formula *=SUM(OFFSET(E10,0,0,E1,1))*. If you move the cursor over *OFFSET(E10,0,0,E1,1),* highlight this part of the formula, and then select F9, you will see *=SUM({135,120,58}),* which indicates that the OFFSET portion of the formula in cell D4 uses the correct cells (D10:D12). Be sure you press Esc to exit this procedure or you will lose your formula!

Another way to see how a complex formula works is to use the Evaluate Formula command. Move the cursor to E4 and click the Formulas tab on the ribbon. In the Formula Auditing group, click Evaluate Formula. (See Figure 22-6.) Click the Evaluate button (it looks like a magnifying glass), and Excel simplifies the formula step by step until you see the formula's final result. After clicking Evaluate twice, the formula appears as *=SUM($E$10:E$12),* so you know that in cell E4 you have selected the Phase 1 cells for Drug 2, which is what you wanted.

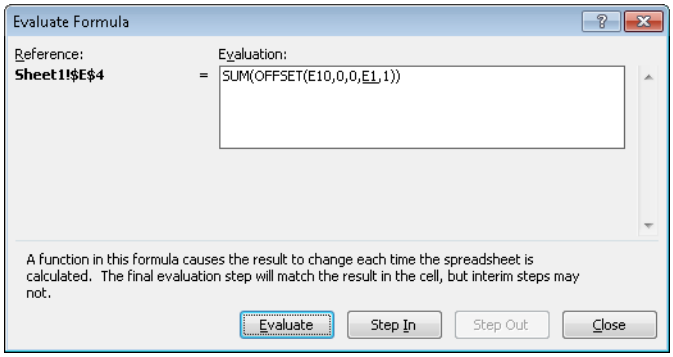


FIGURE 22-6 Evaluate Formula dialog box.

How can I write a formula that always returns the last number in a column?

You often download new data into a worksheet. Can you write a formula that always returns sales during thelas most recent month? (See the file Mostrecent.xlsx and Figure 22-7.)

	B	C	D
3			Most recent
4			110
5			
6	Sales		
7	20		
8	3		
9	40		
10	50		
11	60		
12	90		
13	110		

FIGURE 22-7 Finding the last number in a column.

Simply enter in cell D4 the formula *OFFSET(B6,COUNT(B:B),0,1,1)*.

This formula begins in cell B6 and moves down a number of rows equal to the number of numerical entries in column B. This takes you to the most recent month of sales, which is selected because *1,1* returns only one cell.

How can I set up a range name that automatically includes new data?

Users of Excel often add rows or columns of data to a range of data that is used to create a PivotTable or to perform another type of analysis. Usually, they simply update the range of cells referred to in their formula and then rerun the analysis. However, you can use dynamic range names and never have to update the range of data referred to in a formula or PivotTable. The range will automatically update. Here is an example.

The file Dynamicrange.xlsx shows entries from an HR database. (See Figure 22-8.)

	A	B	C	D	E	F	G
1	Name	Salary	Exp	Gender			
2	John	35500	3	M			
3	Jack	42300	4	M			
4	Jill	53426	5	F	Example of dynamic range		
5	Erica	56000	6	F			
6	JR	62000	8	M			
7	Bianca	49000	10	F			
8	Francis	52000	5	M			
9	Roger	56000	7	M			
10	Maggie	42000	4				
11							448278

FIGURE 22-8 Example of a dynamic range.

Currently, the data contains nine rows and four columns of data. Wouldn't it be nice if you could create a range name that would automatically include more rows and/or columns when you add people or fields of information to the database?

To create a dynamic range, click the Formulas tab and, in the Defined Names group, click Name Manager. Then click New and define a range as shown in Figure 22-9.

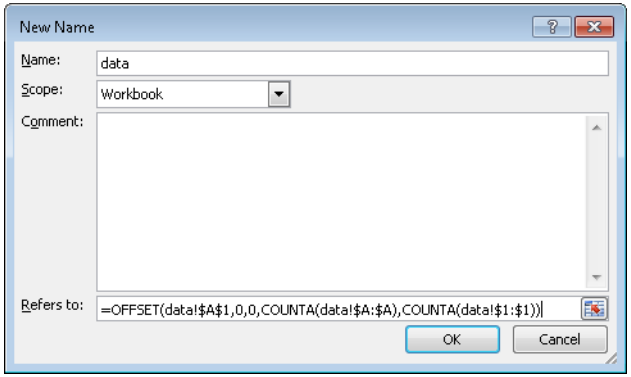


FIGURE 22-9 Creating a dynamic range.

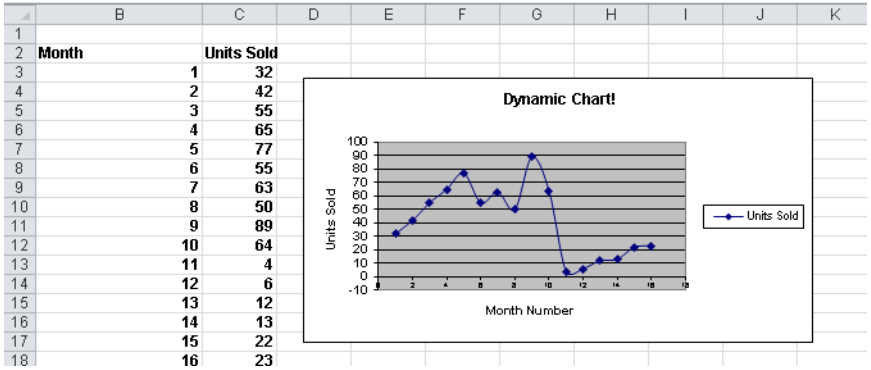
The range starts in the upper-left corner: cell A1. Next we move 0 rows and columns from cell A1. The selected range has *number of rows=number of nonblank entries in column A* and *number of columns=number of nonblank entries in row 1*. Thus, if you add people or data fields, the formula will automatically expand to include them. The dollar signs ($) are needed so that the defined range will not shift if you move around the worksheet.

To try this out, enter the formula *=SUM(data)* in cell G14. At present, this formula totals all numbers in the range A1:D9 and yields $448,278.

Now add to row 10 the name *Meredith*, enter in B10 a salary of $10,000, enter in E1 a variable for Mistakes (add the word *Mistakes*), and in E10 enter 1,000. The formula *=SUM(data)* now includes the 10,000 and 1,000, and automatically updates to $459,278.

I am charting my company's monthly unit sales. Each month I download the most recent month's unit sales. I would like my chart to update automatically. Is there an easy way to accomplish this?

The workbook Chartdynamicrange.xlsx (see Figure 22-10) contains the units sold of your company's product. As you can see, the units sold have been charted using an XY (Scatter) chart.



	Month	Units Sold
1	1	32
2	2	42
3	3	55
4	4	65
5	5	77
6	6	55
7	7	63
8	8	50
9	9	89
10	10	64
11	11	4
12	12	6
13	13	12
14	14	13
15	15	22
16	16	23

FIGURE 22-10 You can use the OFFSET function to update this chart dynamically.

Beginning in row 19, you download new sales data. Is there an easy way to ensure that the chart automatically includes the new data?

The key to updating the chart is to use the OFFSET function to create dynamic range names for both the Months column and the Units Sold column. As new data is entered, the dynamic range for unit sales will automatically include all sales data, and the dynamic range for months will include each month number. After creating these ranges, you can modify the chart, replacing the data ranges used in the chart with the dynamic ranges. The chart now updates as new data is entered.

To begin, click Define Names on the Formulas tab on the ribbon to display the New Name dialog box. Create a range named *Units* by filling in the dialog box as shown in Figure 22-11.

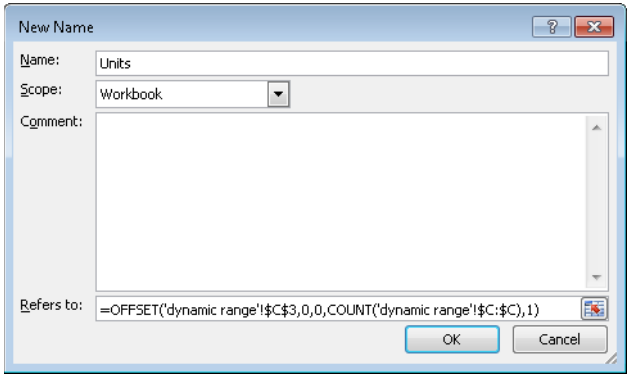


FIGURE 22-11 Creating a dynamic range name for the units sold.

Entering *=OFFSET('dynamic range'!$C$3,0,0,COUNT(!$C:$C),1)* in the Refers To area of the dialog box creates a range one column wide beginning in cell C3, which contains the first unit sales data point. The range will contain as many numbers as there are in column C, which is derived by the portion of the formula that reads *COUNT('dynamic range'!$C:$C)*. As new data is entered into column C, the data is automatically included in the range named *Units*.

Next, create a dynamic range named Month for the months entered in column B. The formula is shown in Figure 22-12.

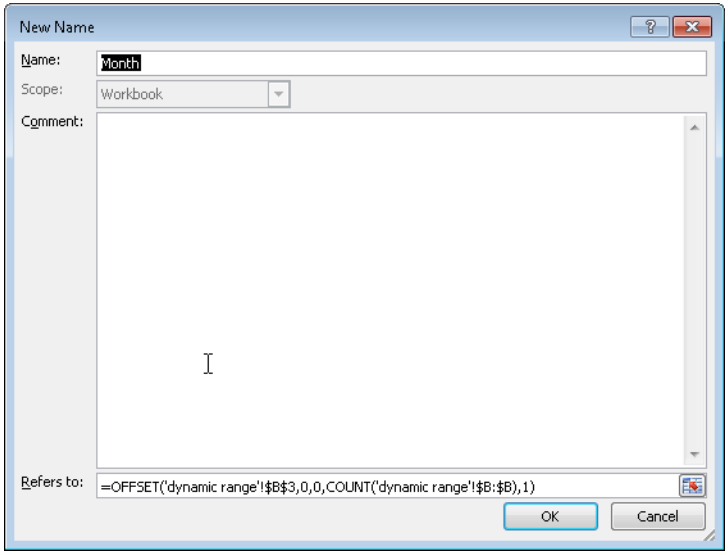


FIGURE 22-12 The formula used to define a dynamic range named *Month*.

Now go to the chart and click any point. In the formula box, you'll see the formula *SERIES('dynamic range'!$C$2,'dynamic range'!$B$3:$B$18,'dynamic range'!$C$3:$C$18,1)*. This formula is Excel's version of the data originally used to set up the chart. Replace the ranges $B$3:$B$18 and $C$3:$C18 with the dynamic range names as follows: *SERIES('dynamic range'!$C$2,Chartdynamicrange.xlsx!Month,Chartdynamicrange.xlsx!Units,1)*. Of course, if a blank space is listed above any new data, this method won't work. Enter some new data, and you'll see that it is included in the chart.

Remarks

The Excel table feature makes it easy to set things up so that charts and formulas automatically incorporate new data. See Chapter 26, "Tables," for a discussion of this feature.

Problems

1. The file C22p1.xlsx contains data about unit sales for 11 products during the years 1999–2003. Write a formula using the MATCH and OFFSET functions that determines the sales of a given product during a given year. Can you think of another way to solve this problem without using the MATCH and OFFSET functions?

2. A commonly suggested moving average trading rule is to buy a stock when its price moves above the average of the last *D* months and to sell it when its price moves below the average of the last *D* months. In Chapter 12, "IF Statements," I showed that for *D=15*, this trading rule outperformed the Standard &Poor's 500 by a substantial amount. By combining a one-way data table with the OFFSET function, determine the value of *D* that maximizes trading profit (excluding transactions costs). You can find pertinent data in the file Matradingrule.xlsx.

3. A commonly suggested moving average trading rule is to buy a stock when its price moves above the average of the last *B* months and to sell it when its price moves below the average of the last *S* months. In Chapter 13, "Time and Time Functions," I showed that for *B=S=15*, this trading rule outperformed the Standard & Poor's 500 by a substantial amount. By combining a two-way data table with the OFFSET function, determine the values of *B* and *S* that maximize trading profit (excluding transactions costs). You'll find data for this problem in the file Matradingrule.xlsx.

4. The file Lagged.xlsx contains data about the number of magazine ads placed by U.S. Army Recruiting during each of 60 consecutive months. For each month, the *k*-month lagged number of ads is defined to equal the number of ads placed *k* months ago. For months 7–60, you want to compute the 1-month lagged, 2-month lagged, through 6-month lagged values of the number of ads. Use the OFFSET function to efficiently compute these lagged values.

5. The file Verizondata.xlsx gives sales of four different Verizon phones in five regions. Determine an efficient method to enter for each of the 20 region-product combinations, the region, type of phone, and sales of each phone into one row.

6. This problem is a difficult one. The file Agingdata.xlsx gives the number of insurance claims projected to be received daily and the number of insurance company workers available. Each day, a worker can process up to 30 claims. Workers process the oldest claims in the system first. Cells H6:AL6 contain the number of claims already in the system on January 1, before new claims arrive. Set up a worksheet to track the "aging" of the claims. That is, for each day, how many 1-day old , 2-day old, … 30-day old, and over 30-day old claims will be in the system.

7. Each row of the file Tapesales.xlsx contains monthly sales of a video tape. Write a formula to determine sales for each tape during its first six months on the market.

8. To obtain a golfer's handicap, you average the 10 lowest of the golfer's last 20 rounds. Then you subtract 80 and round to the nearest integer. Thus, if the 10 lowest of the last 20 rounds adds up to 864, the handicap would be 6. The file Golfdata.xlsx contains a golfer's scores. Beginning in row 24, compute the golfer's handicap after each round. Assume that if the tenth best score in the last 20 rounds occurs more than once, then all rounds including that score will be included in the handicap calculation. Note that the Excel function *=ROUND(x,0)* will round *x* to the nearest integer.

9. Each row of the file Carsumdata.xlsx contains sales data for a product (car, train, or plane) from January thru July. Suppose you enter a month and a product into the worksheet. Write a formula that gives the total sales of that product during the given month.

10. The file Verizon.xlsx contains monthly returns on Verizon stock. Use the OFFSET function to extract all the January returns to one column, all the February returns to one column, and so on.

11. The file Casesensitive.xlsx contains product codes and product prices. Note that the product codes are case sensitive. For example, DAG32 is not the same product as dag32. Write a formula that gives the product price for any product code.
Hint: You might need to use the EXACT function. The formula *EXACT(cell1,cell2)* yields True if cell1 and cell2 have exactly the same contents. EXACT differentiates between uppercase and lowercase letters.

12. The file Reversed.xlsx contains a column of numbers. Use the OFFSET function to "reverse" the numbers so that the number on bottom occurs on top, and so on.

13. The file Diagonal.xls contains a matrix of numbers. Determine how to put the diagonal elements of the matrix in a single column.

14. The file Yeartodate.xlsx contains a company's monthly sales during the years 2008–2014. Write a formula that returns for a given year and month of a year, the year's cumulative sales to date. For example, if you enter a 6 for the month and 2010 for the year, your formula should compute total sales for the period January–June 2010.

15. Show how you might create a graph of monthly sales that always displays just the last six months of sales.

16. The file Transactiondata.xlsx contains sales transactions in divisions A, B, C, D, and E of a drug company. Use the OFFSET function to modify this data so that the sales for each division appear in a single row.

Chapter 44

Sparklines

Questions answered in this chapter:

- How can you graphically summarize daily customer counts for each of a bank's branches in a single cell?
- How can you modify sparklines?
- How can you summarize an NFL team's sequence of wins or losses in a single cell?
- Do sparklines automatically update when new data is included?

Sparklines are exciting graphics that can summarize a row or column of data in a single cell. The term *sparkline* was first used by Edward Tufte, a famous expert on the visual presentation of data and its analysis. Tufte described sparklines as "data-intense, design-simple, word-sized graphics." Microsoft Excel 2010 makes it a snap to create amazing graphics that reside in a single cell.

Answers to This Chapter's Questions

How can you graphically summarize daily customer counts for each of a bank's branches in a single cell?

The file Sparklines.xlsx contains daily customer counts at several branches of a New York state bank. See Figure 44-1.

	C	D	E	F	G	H	I
7		Monday	Tuesday	Wednesda	Thursday	Friday	Summary
8	New York	1176	768	808	864	1235	
9	Rochester	475	323	333	356	515	
10	Utica	360	250	228	275	378	
11	Syracuse	594	412	408	459	618	
12	Buffalo	698	475	504	551	803	
13	Ossining	306	208	204	234	322	
14	Ithaca	437	288	294	299	450	

FIGURE 44-1 Data for sparklines.

Let's say that you want to summarize the weekly customer counts by graphing the daily counts for each branch in a single cell. Simply select the range where you want your sparklines to go (I chose I8:I14), and then from the Insert tab, select Line from the Sparklines group shown in Figure 44-2.

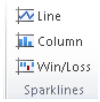


FIGURE 44-2 Sparkline choices.

Then fill in the dialog box below with the data on which the sparklines are based (D8:H14).

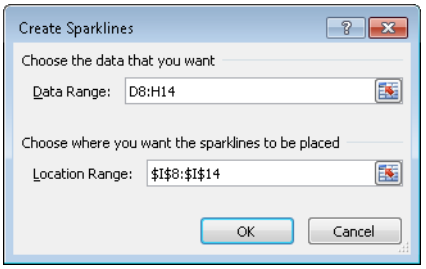


FIGURE 44-3 Creating line sparklines.

You now see a line graph (Figure 44-4) that summarizes the customer traffic for each branch. You can see this in the worksheet *Line Sparkline* in the file Sparklines.xlsx.

	C	D	E	F	G	H	I
7		Monday	Tuesday	Wednesday	Thursday	Friday	Summary
8	New York	1176	768	808	864	1235	
9	Rochester	475	323	333	356	515	
10	Utica	360	250	228	275	378	
11	Syracuse	594	412	408	459	618	
12	Buffalo	698	475	504	551	803	
13	Ossining	306	208	204	234	322	
14	Ithaca	437	288	294	299	450	

FIGURE 44-4 Line sparklines summarizing branch traffic.

You can see that for each branch, Monday and Friday are clearly the busiest days.

How can you modify sparklines?

If you click in any cell containing a sparkline, the Sparkline Tools Design tab appears. After selecting the Design tab, you can make many changes to your sparklines. For example, as shown in Figure 44-5, I selected the high and low points to be marked.

The resulting sparklines are shown in Figure 44-6. See the worksheet *High Low* in file Sparklines.xlsx.

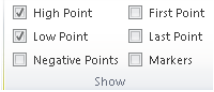


FIGURE 44-5 Selecting high and low points to mark on sparklines.

	C	D	E	F	G	H	I
7		Monday	Tuesday	Wednesd	Thursday	Friday	Summary
8	New York	1176	768	808	864	1235	
9	Rochester	475	323	333	356	515	
10	Utica	360	250	228	275	378	
11	Syracuse	594	412	408	459	618	
12	Buffalo	698	475	504	551	803	
13	Ossining	306	208	204	234	322	
14	Ithaca	437	288	294	299	450	

FIGURE 44-6 High and low points marked on sparklines.

These sparklines make it clear that Friday is the busiest day for each branch and Tuesday or Wednesday is the least busy day.

From the Design tab you can make the following changes to your sparklines:

- Change the type of sparkline (line, column, or win/loss). I discuss column and win/loss sparklines later in the chapter.
- Use the Edit Data command to change the data used to create the sparklines. You can also change the default setting so that hidden data is included in your sparklines.
- Select any combination of the high point, low point, negative points, first point, or last point to be marked.
- Change the style or color associated with the sparklines and/or sparkline markers.
- By selecting Axis, you can change the way the axes are set for each sparkline. For example, you can make the x-axis or y-axis scale the same for each sparkline. The default is to base the scale for each axis on the data for the individual sparkline. This is the scaling used in Figure 44-4. The Custom option allows you to pick an upper and lower limit for each axis.
- When data points occur at irregularly spaced dates, you can select Data Axis from the Axis option so that the graphed points are separated by an amount of space proportional to the differences in dates. Figure 44-7 shows company sales at irregularly spaced dates (see the worksheet *Date Axis* in the file Sparklines.xlsx). In cell F12, the sparkline is graphed as though the dates are spaced at regular intervals. After clicking Axis and choosing the range C10:C13 to use as the data axis, the sparkline in cell F10 reflects the irregular date spacing.

	C	D	E	F	G
9	Date	Sales			
10	1/1/2010	1000			Date axis
11	6/1/2010	1200			
12	9/1/2012	1400			No date axis
13	1/1/2015	1900			

FIGURE 44-7 Sparklines with a data axis.

You can also change line sparklines to column sparklines by clicking any sparkline and then selecting Column from the Sparklines Tools Design tab. See Figure 44-8 and the worksheet *Column Sparkline* in the file Sparklines.xlsx.

	C	D	E	F	G	H	I
7		Monday	Tuesday	Wednesday	Thursday	Friday	Summary
8	New York	1176	768	808	864	1235	
9	Rochester	475	323	333	356	515	
10	Utica	360	250	228	275	378	
11	Syracuse	594	412	408	459	618	
12	Buffalo	698	475	504	551	803	
13	Ossining	306	208	204	234	322	
14	Ithaca	437	288	294	299	450	

FIGURE 44-8 Column sparkline graph.

How can you summarize an NFL team's sequence of wins or losses in a single cell?

The file Nflwinslosses.xlsx contains the game by game performance for each NFL team during the 2009 regular season. A subset of this data is shown in Figure 44-9 (see the *Win Loss* worksheet).

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
21		Indianapolis Colts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	-1
22		Jacksonville Jaguars	-1	-1	1	1	-1	1	-1	1	1	1	-1	1	-1	-1	-1	-1
23		Kansas City Chiefs	-1	-1	-1	-1	-1	1	-1	-1	1	1	-1	-1	-1	-1	-1	1
24		Miami Dolphins	-1	-1	-1	1	1	-1	1	-1	1	1	-1	1	1	-1	-1	-1
25		Minnesota Vikings	1	1	1	1	1	1	-1	1	1	1	1	-1	1	-1	-1	1
26		New England Patriots	1	-1	1	1	-1	1	1	1	-1	1	-1	-1	1	1	1	-1
27		New Orleans Saints	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	-1	-1
28		New York Giants	1	1	1	1	1	-1	-1	-1	-1	1	-1	1	-1	1	-1	-1
29		New York Jets	1	1	1	-1	-1	-1	1	-1	-1	-1	1	1	1	-1	1	1
30		Oakland Raiders	-1	1	-1	-1	-1	1	-1	-1	-1	1	-1	1	-1	1	-1	-1
31		Philadelphia Eagles	1	-1	1	1	-1	1	1	-1	-1	1	1	1	1	1	1	-1
32		Pittsburgh Steelers	1	-1	-1	1	1	1	1	1	-1	-1	-1	-1	-1	1	1	1
33		San Diego Chargers	1	-1	1	-1	-1	1	1	1	1	1	1	1	1	1	1	1
34		San Francisco 49ers	1	1	-1	1	-1	-1	-1	-1	1	-1	1	-1	1	-1	1	1
35		Seattle Seahawks	1	-1	-1	-1	1	-1	-1	1	-1	-1	1	1	-1	-1	-1	-1
36		St. Louis Rams	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1
37		Tampa Bay Buccaneers	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	1	1	-1
38		Tennessee Titans	-1	-1	-1	-1	-1	-1	1	1	1	1	1	-1	1	1	-1	1

FIGURE 44-9 Sparklines summarizing wins and losses for NFL teams.

A 1 denotes a win, and a –1 a loss. Each win/loss sparkline treats any positive number as an "up block" and any negative number as a "down block." Any 0s are graphed as a gap. To create the win/loss sparklines, select the range where the sparklines should be placed (cell range C8:C39), and then select Win/Loss from the Sparklines group on the Insert menu. Next, choose the data range E8:T39. The sparklines make the 2009 NFL season come alive. You can see the amazing starts of the Indianapolis Colts and the New Orleans Saints. You can see that the Tennessee Titans started poorly and then got red hot. The New York Giants started well and then hit a rough patch. Win/loss sparklines are great for tracking an organization's progress toward meeting quotas or goals. See Problem 4 at the end of this chapter.

Do Sparklines automatically update when new data is included?

If you want your sparklines to automatically update to include new data, you should make the data a table (see Chapter 26, "Tables") or convert the data into a dynamic range (see Chapter 22, "The OFFSET Function.")

Problems

1. For the bank branch data, make your line sparklines use the same scale for each branch.
2. The data Dow.xlsx contains the values of the Dow Jones Index for January 2–August 10, 2010. Create a line sparkline to show the ups and downs of the market.
3. Use win/loss sparklines to capture the market's ups and downs. Again use the file Dow.xlsx.
4. The file Goals.xlsx shows the percentage amount by which bank branches met or failed to meet their goals each month. Summarize this data with win/loss sparklines.

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About the Author

Wayne Winston, professor of operations and decision technologies at Indiana University and an Eli Lilly & Co. faculty fellow, developed this tutorial to provide users of Microsoft Excel with a comprehensive understanding of spreadsheet modeling. For more than 10 years, Wayne has taught Excel modeling to thousands of analysts at organizations such as Microsoft, Eli Lilly, Cisco, eBay, the U.S. Army, General Motors, Ford, Pfizer, and Verizon. He has won more than 25 teaching awards. Wayne also consults for the Dallas Mavericks NBA team. His book on math and sports, *Mathletics,* was published in 2009 by Princeton University Press. Wayne is a two time *Jeopardy!* champion.