Appendices

APPENDIX A Basic Math Concepts and Symbols

A.1 Rules for Arithmetic Operations

RULE	EXAMPLE
1. $a + b = c$ and $b + a = c$	$2 + 1 = 3$ and $1 + 2 = 3$
2. $a + (b + c) = (a + b) + c$	$5 + (7 + 4) = (5 + 7) + 4 = 16$
3. $a - b = c$ but $b - a \neq c$	$9 - 7 = 2$ but $7 - 9 \neq 2$
4. $(a)(b) = (b)(a)$	$(7)(6) = (6)(7) = 42$
5. $(a)(b + c) = ab + ac$	$(2)(3 + 5) = (2)(3) + (2)(5) = 16$
6. $a \div b \neq b \div a$	$12 \div 3 \neq 3 \div 12$
7. $\frac{a + b}{c} = \frac{a}{c} + \frac{b}{c}$	$\frac{7 + 3}{2} = \frac{7}{2} + \frac{3}{2} = 5$
8. $\frac{a}{b + c} \neq \frac{a}{b} + \frac{a}{c}$	$\frac{3}{4 + 5} \neq \frac{3}{4} + \frac{3}{5}$
9. $\frac{1}{a} + \frac{1}{b} = \frac{b + a}{ab}$	$\frac{1}{3} + \frac{1}{5} = \frac{5 + 3}{(3)(5)} = \frac{8}{15}$
10. $\left(\frac{a}{b}\right)\left(\frac{c}{d}\right) = \left(\frac{ac}{bd}\right)$	$\left(\frac{2}{3}\right)\left(\frac{6}{7}\right) = \left(\frac{(2)(6)}{(3)(7)}\right) = \frac{12}{21}$
11. $\frac{a}{b} \div \frac{c}{d} = \frac{ad}{bc}$	$\frac{5}{8} \div \frac{3}{7} = \left(\frac{(5)(7)}{(8)(3)}\right) = \frac{35}{24}$

A.2 Rules for Algebra: Exponents and Square Roots

RULE	EXAMPLE
1. $(X^a)(X^b) = X^{a+b}$	$(4^2)(4^3) = 4^5$
2. $(X^a)^b = X^{ab}$	$(2^2)^3 = 2^6$
3. $(X^a/X^b) = X^{a-b}$	$\frac{3^5}{3^3} = 3^2$
4. $\frac{X^a}{X^a} = X^0 = 1$	$\frac{3^4}{3^4} = 3^0 = 1$
5. $\sqrt{XY} = \sqrt{X}\sqrt{Y}$	$\sqrt{(25)(4)} = \sqrt{25}\sqrt{4} = 10$
6. $\sqrt{\frac{X}{Y}} = \frac{\sqrt{X}}{\sqrt{Y}}$	$\sqrt{\frac{16}{100}} = \frac{\sqrt{16}}{\sqrt{100}} = 0.40$

A.3 Rules for Logarithms

Base 10

Log is the symbol used for base-10 logarithms:

RULE	EXAMPLE
1. $\log(10^a) = a$	$\log(100) = \log(10^2) = 2$
2. If $\log(a) = b$, then $a = 10^b$	If $\log(a) = 2$, then $a = 10^2 = 100$
3. $\log(ab) = \log(a) + \log(b)$	$\log(100) = \log[(10)(10)] = \log(10) + \log(10)$ $= 1 + 1 = 2$
4. $\log(a^b) = (b)\log(a)$	$\log(1{,}000) = \log(10^3) = (3)\log(10) = (3)(1) = 3$
5. $\log(a/b) = \log(a) - \log(b)$	$\log(100) = \log(1{,}000/10) = \log(1{,}000) - \log(10)$ $= 3 - 1 = 2$

EXAMPLE

Take the base-10 logarithm of each side of the following equation:

$$Y = \beta_0\beta_1^X\varepsilon$$

SOLUTION: Apply rules 3 and 4:

$$\begin{aligned}\log(Y) &= \log(\beta_0\beta_1^X\varepsilon)\\ &= \log(\beta_0) + \log(\beta_1^X) + \log(\varepsilon)\\ &= \log(\beta_0) + X\log(\beta_1) + \log(\varepsilon)\end{aligned}$$

Base *e*

ln is the symbol used for base *e* logarithms, commonly referred to as natural logarithms. *e* is Euler's number, and $e \cong 2.718282$:

RULE	EXAMPLE
1. $\ln(e^a) = a$	$\ln(7.389056) = \ln(e^2) = 2$
2. If $\ln(a) = b$, then $a = e^b$	If $\ln(a) = 2$, then $a = e^2 = 7.389056$
3. $\ln(ab) = \ln(a) + \ln(b)$	$\ln(100) = \ln[(10)(10)]$ $= \ln(10) + \ln(10) = 2.302585 + 2.302585 = 4.605170$
4. $\ln(a^b) = (b)\ln(a)$	$\ln(1{,}000) = \ln(10^3) = 3\ln(10) = 3(2.302585) = 6.907755$
5. $\ln(a/b) = \ln(a) - \ln(b)$	$\ln(100) = \ln(1{,}000/10) = \ln(1{,}000) - \ln(10)$ $= 6.907755 - 2.302585 = 4.605170$

EXAMPLE

Take the base *e* logarithm of each side of the following equation:

$$Y = \beta_0\beta_1^X\varepsilon$$

SOLUTION: Apply rules 3 and 4:

$$\begin{aligned}\ln(Y) &= \ln(\beta_0\beta_1^X\varepsilon)\\ &= \ln(\beta_0) + \ln(\beta_1^X) + \ln(\varepsilon)\\ &= \ln(\beta_0) + X\ln(\beta_1) + \ln(\varepsilon)\end{aligned}$$

A.4 Summation Notation

The symbol Σ, the Greek capital letter sigma, represents "taking the sum of." Consider a set of n values for variable X. The expression $\sum_{i=1}^{n} X_i$ means to take the sum of the n values for variable X. Thus:

$$\sum_{i=1}^{n} X_i = X_1 + X_2 + X_3 + \cdots + X_n$$

The following problem illustrates the use of the symbol Σ. Consider five values of a variable X: $X_1 = 2, X_2 = 0, X_3 = -1, X_4 = 5$, and $X_5 = 7$. Thus:

$$\sum_{i=1}^{5} X_i = X_1 + X_2 + X_3 + X_4 + X_5 = 2 + 0 + (-1) + 5 + 7 = 13$$

In statistics, the squared values of a variable are often summed. Thus:

$$\sum_{i=1}^{n} X_i^2 = X_1^2 + X_2^2 + X_3^2 + \cdots + X_n^2$$

and, in the example above:

$$\begin{aligned}\sum_{i=1}^{5} X_i^2 &= X_1^2 + X_2^2 + X_3^2 + X_4^2 + X_5^2 \\ &= 2^2 + 0^2 + (-1)^2 + 5^2 + 7^2 \\ &= 4 + 0 + 1 + 25 + 49 \\ &= 79\end{aligned}$$

$\sum_{i=1}^{n} X_i^2$, the summation of the squares, is *not* the same as $\left(\sum_{i=1}^{n} X_i\right)^2$, the square of the sum:

$$\sum_{i=1}^{n} X_i^2 \neq \left(\sum_{i=1}^{n} X_i\right)^2$$

In the example given above, the summation of squares is equal to 79. This is not equal to the square of the sum, which is $13^2 = 169$.

Another frequently used operation involves the summation of the product. Consider two variables, X and Y, each having n values. Then:

$$\sum_{i=1}^{n} X_i Y_i = X_1 Y_1 + X_2 Y_2 + X_3 Y_3 + \cdots + X_n Y_n$$

Continuing with the previous example, suppose there is a second variable, Y, whose five values are $Y_1 = 1, Y_2 = 3, Y_3 = -2, Y_4 = 4$, and $Y_5 = 3$. Then,

$$\begin{aligned}\sum_{i=1}^{n} X_i Y_i &= X_1 Y_1 + X_2 Y_2 + X_3 Y_3 + X_4 Y_4 + X_5 Y_5 \\ &= (2)(1) + (0)(3) + (-1)(-2) + (5)(4) + (7)(3) \\ &= 2 + 0 + 2 + 20 + 21 \\ &= 45\end{aligned}$$

In computing $\sum_{i=1}^{n} X_i Y_i$, you need to realize that the first value of X is multiplied by the first value of Y, the second value of X is multiplied by the second value of Y, and so on. These products are then summed in order to compute the desired result. However, the summation of products is *not* equal to the product of the individual sums:

$$\sum_{i=1}^{n} X_i Y_i \neq \left(\sum_{i=1}^{n} X_i\right)\left(\sum_{i=1}^{n} Y_i\right)$$

In this example,

$$\sum_{i=1}^{5} X_i = 13$$

and

$$\sum_{i=1}^{5} Y_i = 1 + 3 + (-2) + 4 + 3 = 9$$

so that

$$\left(\sum_{i=1}^{5} X_i\right)\left(\sum_{i=1}^{5} Y_i\right) = (13)(9) = 117$$

However,

$$\sum_{i=1}^{5} X_i Y_i = 45$$

The following table summarizes these results:

VALUE	X_i	Y_i	$X_i Y_i$
1	2	1	2
2	0	3	0
3	−1	−2	2
4	5	4	20
5	7	3	21
	$\sum_{i=1}^{5} X_i = 13$	$\sum_{i=1}^{5} Y_i = 9$	$\sum_{i=1}^{5} X_i Y_i = 45$

Rule 1 The summation of the values of two variables is equal to the sum of the values of each summed variable:

$$\sum_{i=1}^{n} (X_i + Y_i) = \sum_{i=1}^{n} X_i + \sum_{i=1}^{n} Y_i$$

Thus,

$$\begin{aligned}\sum_{i=1}^{5} (X_i + Y_i) &= (2 + 1) + (0 + 3) + (-1 + (-2)) + (5 + 4) + (7 + 3) \\ &= 3 + 3 + (-3) + 9 + 10 \\ &= 22\end{aligned}$$

$$\sum_{i=1}^{5} X_i + \sum_{i=1}^{5} Y_i = 13 + 9 = 22$$

Rule 2 The summation of a difference between the values of two variables is equal to the difference between the summed values of the variables:

$$\sum_{i=1}^{n}(X_i - Y_i) = \sum_{i=1}^{n}X_i - \sum_{i=1}^{n}Y_i$$

Thus,

$$\sum_{i=1}^{5}(X_i - Y_i) = (2 - 1) + (0 - 3) + (-1 - (-2)) + (5 - 4) + (7 - 3)$$
$$= 1 + (-3) + 1 + 1 + 4$$
$$= 4$$

$$\sum_{i=1}^{5}X_i - \sum_{i=1}^{5}Y_i = 13 - 9 = 4$$

Rule 3 The sum of a constant times a variable is equal to that constant times the sum of the values of the variable:

$$\sum_{i=1}^{n}cX_i = c\sum_{i=1}^{n}X_i$$

where c is a constant. Thus, if $c = 2$,

$$\sum_{i=1}^{5}cX_i = \sum_{i=1}^{5}2X_i = (2)(2) + (2)(0) + (2)(-1) + (2)(5) + (2)(7)$$
$$= 4 + 0 + (-2) + 10 + 14$$
$$= 26$$

$$c\sum_{i=1}^{5}X_i = 2\sum_{i=1}^{5}X_i = (2)(13) = 26$$

Rule 4 A constant summed n times will be equal to n times the value of the constant.

$$\sum_{i=1}^{n}c = nc$$

where c is a constant. Thus, if the constant $c = 2$ is summed 5 times,

$$\sum_{i=1}^{5}c = 2 + 2 + 2 + 2 + 2 = 10$$
$$nc = (5)(2) = 10$$

EXAMPLE

Suppose there are six values for the variables X and Y, such that $X_1 = 2, X_2 = 1, X_3 = 5, X_4 = -3, X_5 = 1, X_6 = -2$ and $Y_1 = 4, Y_2 = 0, Y_3 = -1, Y_4 = 2, Y_5 = 7,$ and $Y_6 = -3$. Compute each of the following:

(a) $\sum_{i=1}^{6}X_i$

(b) $\sum_{i=1}^{6}Y_i$

(c) $\sum_{i=1}^{6}X_i^2$

(d) $\sum_{i=1}^{6}Y_i^2$

(e) $\sum_{i=1}^{6}X_iY_i$

(f) $\sum_{i=1}^{6}(X_i + Y_i)$

(g) $\sum_{i=1}^{6}(X_i - Y_i)$

(h) $\sum_{i=1}^{6}(X_i - 3Y_i + 2X_i^2)$

(i) $\sum_{i=1}^{6}(cX_i)$, where $c = -1$

(j) $\sum_{i=1}^{6}(X_i - 3Y_i + c)$, where $c = +3$

Answers

(a) 4 (b) 9 (c) 44 (d) 79 (e) 10 (f) 13 (g) −5 (h) 65 (i) −4 (j) −5

References

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3. Levine, D. and A. Brandwein, *The MBA Primer: Business Statistics*, 3rd ed. (Cincinnati, OH: Cengage Publishing, 2011).
4. Levine, D., *Statistics* (Hicksville, NY: Video Aided Instruction, 2006).
5. Shane, H., *Algebra 1* (Hicksville, NY: Video Aided Instruction, 2006).

A.5 Statistical Symbols

$+$ add

$-$ subtract

$=$ equal to

$\cong$ approximately equal to

$>$ greater than

$\geq$ greater than or equal to

$\times$ multiply

$\div$ divide

$\neq$ not equal to

$<$ less than

$\leq$ less than or equal to

A.6 Greek Alphabet

GREEK LETTER		LETTER NAME	ENGLISH EQUIVALENT	GREEK LETTER		LETTER NAME	ENGLISH EQUIVALENT
Α	α	Alpha	a	Ν	ν	Nu	n
Β	β	Beta	b	Ξ	ξ	Xi	x
Γ	γ	Gamma	g	Ο	o	Omicron	ŏ
Δ	δ	Delta	d	Π	π	Pi	p
Ε	ε	Epsilon	ĕ	Ρ	ρ	Rho	r
Ζ	ζ	Zeta	z	Σ	σ	Sigma	s
Η	η	Eta	ē	Τ	τ	Tau	t
Θ	θ	Theta	th	Υ	υ	Upsilon	u
Ι	ι	Iota	i	Φ	ϕ	Phi	ph
Κ	κ	Kappa	k	Χ	χ	Chi	ch
Λ	λ	Lambda	l	Ψ	ψ	Psi	ps
Μ	μ	Mu	m	Ω	ω	Omega	ō

APPENDIX B Basic Computing Skills

B.1 Objects in a Window

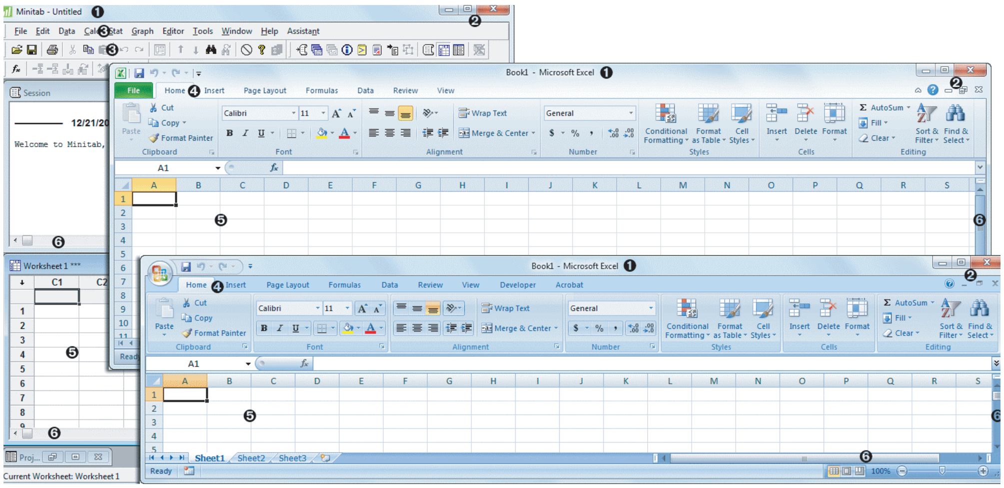
When you open Excel or Minitab, you see a window that contains the objects listed in Table B.1 and shown in Figure B.1. To effectively use Excel or Minitab, you must be familiar with these objects and their names.

TABLE B.1
Common Window Elements

Number	Element	Function
❶	Title bar	Displays the name of the program and contains the Minimize, Resize, and Close buttons for the program window. You drag and drop the title bar to reposition a program window onscreen.
❷	Minimize, Resize, and Close buttons	Changes the display of the program window. **Minimize** hides the window without closing the program, **Resize** permits you to change the size of the window, and **Close** removes the window from the screen and closes the program. A second set of these buttons that appear below the first set perform the three actions for the currently active workbook.
❸	Menu Bar and Toolbars	The menu bar is a horizontal list of words, where each word represents either a command operation or leads to another list of choices. Toolbars are sets of graphical icons that represent commands. The toolbar icons serve as shortcuts to menu bar choices. (Minitab and Excel 2003)
❹	Ribbon	A selectable area that combines the functions of a menu bar and toolbars. In the Ribbon, commands are arranged in a series of **tabs**, and the tabs are further divided into **groups.** Some groups contain **launcher buttons** that display additional choices presented in a dialog box or as a **gallery**, a set of pictorial choices. (Excel 2007 and Excel 2010)
❺	Workbook area	Displays the currently open worksheets. In Excel, this area usually displays the currently active worksheet in the workbook and shows the other worksheets as **sheet tabs** near the bottom of the workbook area.
❻	Scroll bar	Allows you to move through a worksheet vertically or horizontally to reveal rows and columns that cannot otherwise be seen.

FIGURE B.1

Minitab, Excel 2010, and Excel 2007 windows (with number labels keyed to Table B.1)



B.2 Basic Mouse Operations

To interact with the objects in a window, you frequently use a mouse (or some other pointing device). Mouse operations can be divided into four types and assume a mouse with two buttons, one designated as the primary button (typically the left button) and the other button designated as the secondary button (typically the right button).

Click, **select**, **check**, and **clear** are operations in which you move the mouse pointer over an object and press the primary button. **Click** is used when pressing the primary button completes an action, as in "click (the) **OK** (button)." **Select** is used when pressing the primary button to choose or highlight one choice from a list of choices. **Check** is used when pressing the primary button places a checkmark in the dialog box's check box. (**Clear** reverses this action, removing the checkmark.)

Double-click is an operation in which two clicks are made in rapid succession. Most double-click operations enable an object for following use, such as double-clicking a chart in order to make changes to the chart. **Right-click** is an operation in which you move the mouse pointer over an object and press the *secondary* button. In the Excel Guide instructions, you will often right-click an object in order to display a pop-up **shortcut menu** of context-sensitive command operations.

Drag is an operation in which you hold down the primary button over an object and then move the mouse. (The drag operation ends when you release the mouse button.) Dragging is done to select multiple objects, such as selecting all the cells in a cell range, as well as to physically move an object to another part of the screen. The related **drag-and-drop** operation permits you to move one object over another to trigger an action. You drag the first object across the screen, and when the first object is over the second object, you release the primary mouse button. (In most cases, releasing the primary button causes the first object to reappear in its original position onscreen.)

Without a working knowledge of these mousing operations, you will find it difficult to understand and follow the instructions presented in the end-of-chapter Excel and Minitab Guides.

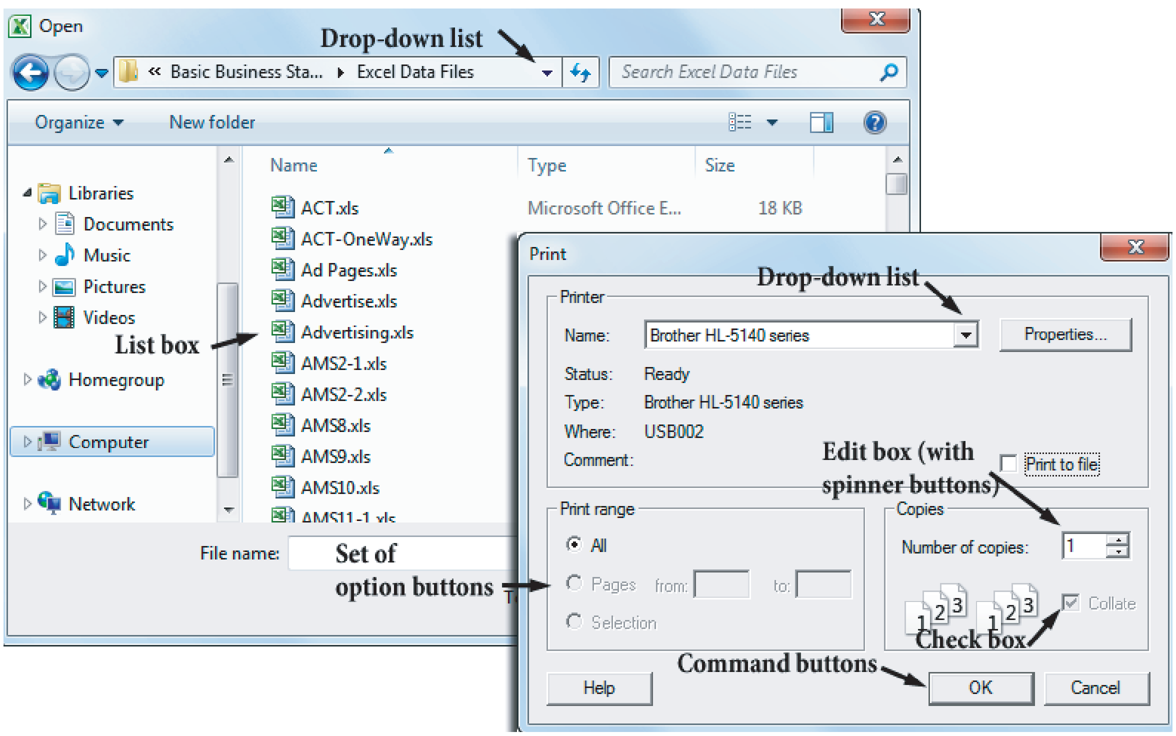
B.3 Dialog Box Interactions

When you interact with either Excel or Minitab, you will see **dialog boxes**, pop-up windows that contain messages or ask you to make entries or selections. Table B.2 identifies and defines the common objects found in dialog boxes which are shown in Figure B.2.

TABLE B.2
Dialog Box Elements

Element	Function
Command button	A clickable area that tells a program to take some action. For example, a dialog box **OK button** causes a program to take an action using the current entries and selections of the dialog box. A dialog box **Cancel button** closes a dialog box and cancels the pending operation associated with the entries and selections in the dialog box.
List box	A box that displays a list of clickable choices. If a list exceeds the dimensions of a list box, list boxes display **scroll buttons** or **sliders** (not shown in Figure B.2) that can be clicked to reveal choices not currently displayed.
Drop-down list	A special button that, when clicked, displays a list of choices from which you typically select one choice.
Edit box	An area into which entries can be typed. Some edit boxes also contain drop-down lists or **spinner buttons** that can be used to make entries. A cell range edit box typically contains a clickable button that allows you to drag the mouse over a cell range as an alternative to typing the cell range.
Set of option buttons	A set of buttons that represent a set of mutually exclusive choices. Clicking one option button clears all the other option buttons in the set.
Check box	A clickable area that represents an optional action. A check box displays either a checkmark or nothing, depending on whether the optional action has been selected. Unlike with option buttons, clicking a check box does not affect the status of other check boxes, and more than one check box can be checked at a time. Clicking a check box that already contains a checkmark *clears* the check box. (To distinguish between the two states, instructions in this book use the verbs *check* and *clear*.)

FIGURE B.2
Excel 2010 Open (partially obscured) and Minitab Print dialog boxes



B.4 Unique Features

Excel 2007 This version of Excel uniquely features the **Office Button**, the circular logo in the upper left of the window that displays a menu of basic computing commands when clicked (see Figure B.1). The Office Button functions much like the File menu in Excel 2003 and Minitab and the File tab in Excel 2010.

Minitab All versions of Minitab use a session manager (shown in Figure MG1.1), a window in which results are added as a continuous log. (All Minitab results, other than charts, shown in this book have been copied from a session manager log.)

Minitab 16 Minitab 16 includes an Assistant feature that helps guide you through the choice of the statistical method to use. The Assistant appears as an additional choice on the Minitab menu bar and also provides direct clickable shortcuts to menu choices that might otherwise require several different mouse clicks to select. The Assistant is not explicitly used in this book due to its uniqueness to Minitab 16.

APPENDIX C Online Resources

C.1 About the Online Resources for This Book

The online resources for this book are the data files for in-chapter examples and problems as well as other files that support your study. Online resources have been grouped into the following categories:

- **Data Files** The files that contain the data used in chapter examples or named in problems. These data files are available as either a set in the. **xls** format (Excel Data Files) or as a set in the **.mtw** format (Minitab Data Files). A complete list of the names of all the data files appear in Section C.4 under the subheading *Data Files.*
- **Excel Guide Workbooks** Workbooks that contain model solutions that can also be reused as templates for solving other problems. A complete list of the names of the Excel Guide Workbooks appear in Section C.4 under the subheading *Excel Guide Workbooks*.
- **Files for the Digital Case** The set of PDF files that support the end-of-chapter Digital Cases. Some of the Digital Case PDF files contain attached or embedded Excel and Minitab files for use with particular case questions.
- **Files for the Managing Ashland MultiComm Services Running Case** The set of data files that support the "Managing Ashland MultiComm Services" running case. These data files are also included in the Data Files set and are listed with the other data files in Section C.4.
- **Online Topics** PDF files that contain additional topics and reference tables for Chapter 5 as well as the full text of Chapter 14, "Statistical Applications in Quality Management."
- **Visual Explorations Files** The files needed to use the Visual Explorations add-in workbook, the interactive Excel add-in that illustrates selected statistical concepts. The add-in workbook requires Excel VBA, found in Microsoft Windows-based Excel 2003, 2007, or 2010 (as well as earlier, retired Excel versions) and in Mac Excel versions other than Excel 2008.
- **PHStat2 Readme File and PHStat2 Setup Program** Files that allow you to use the PHStat2 add-in with Microsoft Windows-Based Excel 2003, 2007, or 2010. The readme file, in PDF format, presents late-breaking news about PHStat2 and reviews all technical and setup requirements. The setup program, a self-extracting **.exe** file, sets up and installs PHStat2 on your Microsoft Windows system. See the end of Section C.4 for more information about setting up and using PHStat2.

To download a set of files, right-click its download link and click the "save as" choice from the shortcut menu (**Save Target As** in Internet Explorer, **Save Link As** in Mozilla Firefox). Other than PHStat2, each set is downloaded as a self-extracting archive of compressed files, which you extract and store in the folder of your choice.

C.2 Accessing the Online Resources

Online resources for this book are available either on the download page for this book or inside the MyMathLab Global course for this book, further explained in Section C.3.

To access the download page for this book, open a web browser and go to **www.pearsoninternationaleditions.com/levine**. On that web page, find the entries for this book and click the link for the download page for this book. On the download page, right-click the download link for one of the resource categories listed in Section C.1. Click the "save as" choice from the shortcut menu (**Save Target As** in Internet Explorer, **Save Link As** in Mozilla Firefox). With the exception of the PHStat2 files, the online resources have been packaged as compressed zip archive files that you download and then expand on your system.

C.3 Accessing the MyMathLab Global Course Online

The MyMathLab Global course for this book contains all of the online resources. Log into the course at the MyMathLab Global website (**www.mymathlab.com/global**) and in the left panel of the course page, click Student Resources and then Tools for Success. On that page, click the link for one of the resource categories listed in Section C.1. With the exception of the PHStat2 link, you will be prompted to download and save a compressed zip archive file that you later expand on your system. The PHStat2 link leads to a separate web page from which you can download the PHStat2 readme file and the PHStat2 setup file. Using MyMathLab Global requires that you have an access code for this book. An access code may have been packaged with this book. If your book did not come with an access code, you can purchase access online at **www.mymathlab.com/global**.

C.4 Details of Downloadable Files

Data Files

Data files contain the data used in chapter examples or named in problems. Throughout this book, the names of data files appear in a special invert color typeface—for example, Bond Funds.

Data files are available as either a set in the **.xls** format (Excel workbook files), compatible with all Excel versions, or as a set in the **.mtw** format (Minitab worksheet files), compatible with Minitab Release 14 or later. Excel and Minitab worksheets organize the data for each variable by column, using the rules discussed in Sections EG1.2 and MG1.2. Except where noted in this book, each Excel **.xls** workbook file stores data in a worksheet named **DATA**.

In the following alphabetical list, the variables for each data file are presented in the order of their appearance in the file's worksheet. References to the chapters in which the file is mentioned appears in parentheses.

AD PAGES Magazine name, magazine ad pages in 2008, and magazine ad pages in 2009 (Chapter 10)

ADVERTISE Sales ($thousands), radio ads ($thousands), and newspaper ads ($thousands) for 22 cities (Chapter 13)

AMS2-1 Types of errors and frequency; types of errors and cost; types of wrong billing errors and cost (Chapter 2)

AMS2-2 Days and number of calls (Chapter 2)

AMS8 Rate willing to pay in $ (Chapter 8)

AMS9 Upload speed (Chapter 9)

AMS10-1 Update times for e-mail interface 1 and email interface 2 (Chapter 10)

AMS10-2 Update time for system 1, system 2, and system 3 (Chapter 10)

AMS12 Number of hours spent telemarketing and number of new subscriptions (Chapter 12)

AMS13 Week, number of new subscriptions, hours spent telemarketing, and type of presentation (formal or informal) (Chapter 13)

AMS14 Day and upload speed (Chapter 14)

ANGLE Subgroup number and angle (Chapter 14)

ANSCOMBE Data sets A, B, C, and D—each with 11 pairs of X and Y values (Chapter 12)

ATM TRANSACTIONS Cause, frequency, and percentage (Chapter 2)

AUDITS Year and number of audits (Chapter 2)

AUTO 2011 Car, miles per gallon, horsepower, and weight (in lb.) (Chapters 12 and 13)

BANK1 Waiting time (in minutes) of 15 customers at a bank located in a commercial district (Chapters 3 and 9)

BANK2 Waiting time (in minutes) of 15 customers at a bank located in a residential area (Chapter 3)

BANKTIME Day, waiting times of four bank customers (A, B, C, and D) (Chapter 14)

BB2010 Team, league (0 = American, 1 = National), wins, earned run average and runs scored (Chapters 12 and 13)

BBCOST2010 Team and fan cost index (Chapters 2 and 6)

BESTFUNDS Fund type (large cap value, large cap growth), 3-year return, 5-year return, 10-year return, expense ratio (Chapter 10)

BESTFUNDS2 Fund type (foreign large cap blend, small cap blend, midcap blend, large cap blend, diversified emerging markets), 3-year return, 5-year return, 10-year return, expense ratio (Chapter 10)

BESTFUNDS3 Fund type (intermediate municipal bond, short-term bond, intermediate term bond), 3-year return, 5-year return, 10-year return, expense ratio (Chapter 10)

BILL PAYMENT Form of payment and percentage (Chapter 2)

BOND FUNDS Fund number, type, assets, fees, expense ratio, 2009 return, 3-year return, 5-year return, risk, bins, and midpoints (Chapters 2, 3, 4, 6, 8, 10, and 11)

BOND FUNDS2008 Fund number, type, assets, fees, expense ratio, 2008 return, 3-year return, 5-year return, risk, bins, and midpoints (Chapters 2 and 3)

BOOKPRICES Author, title, bookstore price, and online price (Chapter 10)

BULBS Manufacturer (1 = A, 2 = B) and length of life in hours (Chapters 2 and 10)

CANISTER Day and number of nonconformances (Chapter 14)

CATFOOD Ounces eaten of kidney, shrimp, chicken liver, salmon, and beef cat food (Chapter 10)

CATFOOD3 Type (1 = kidney, 2 = shrimp), shift, time interval, nonconformances, and volume (Chapter 14)

CATFOOD4 Type (1 = kidney, 2 = shrimp), shift, time interval, and weight (Chapter 14)

CD RATE One-year and five-year CD rate (Chapters 2, 3, 6, 8)

CEO-COMPENSATION Company, compensation of CEO in $millions, and return in 2010 (Chapters 2, 3, and 12)

CEREALS Cereal, calories, carbohydrates, and sugar (Chapters 3 and 12)

CIGARETTETAX State and cigarette tax ($) (Chapters 2 and 3)

COFFEESALES Coffee sales at $0.59, $0.69, $0.79, and $0.89 (Chapter 10)

COLA Sales for normal and end-aisle locations (Chapter 10)

COLASPC Day, total number of cans filled, and number of unacceptable cans (Chapter 14)

COLLEGE BASKETBALL School, coach's total salary in $thousands, expenses, and revenues ($thousands) (Chapters 2, 3, and 12)

CONCRETE1 Sample number and compressive strength after two days and seven days (Chapter 10)

CRACK Type of crack (0 = unflawed, 1 = flawed) and crack size (Chapter 10)

CURRENCY Year, coded year, and exchange rates (against the U.S. dollar) for the Canadian dollar, Japanese yen, and English pound (Chapter 2)

CUSTSALE Week number, number of customers, and sales ($thousands) over a period of 15 consecutive weeks (Chapter 12)

DARKCHOCOLATE Cost ($) per ounce of dark chocolate bars (Chapters 2 and 8)

DELIVERY Customer number, number of cases, and delivery time (Chapter 12)

DIGITALCAMERAS Battery life (in shots) for subcompact cameras and compact cameras (Chapter 10)

DINNER Time to prepare and cook dinner (in minutes) (Chapter 9)

DOMESTICBEER Brand, alcohol percentage, calories, and carbohydrates in U.S. domestic beers (Chapters 2, 3, and 6)

DOWMARKETCAP Company and market capitalization ($billions), (Chapters 3 and 6)

DRILL Depth, time to drill additional 5 feet, and type of hole (Chapter 13)

DRINK Amount of soft drink filled in 2-liter bottles (Chapter 9)

ENERGY State and per capita kilowatt hour use (Chapter 3)

ERRORSPC Number of nonconforming items and number of accounts processed (Chapter 14)

ERWAITING Emergency room waiting time (in minutes) at the main facility and at satellite 1, satellite 2, and satellite 3 (Chapter 10)

ESPRESSO Tamp (the distance in inches between the espresso grounds and the top of the portafilter) and time (the number of seconds the heart, body, and crema are separated) (Chapter 12)

FASTFOOD Amount spent on fast food in dollars (Chapters 8 and 9)

FIVE YEAR CD RATE Five year CD rate in New York and Los Angeles (Chapter 10)

FORCE Force required to break an insulator (Chapters 3, 8, and 9)

FOULSPC Number of foul shots made and number taken (Chapter 14)

FUNDTRAN Day, number of new investigations, and number of investigations closed (Chapter 14)

FURNITURE Days between receipt and resolution of complaints regarding purchased furniture (Chapters 2, 3, 8, and 9)

GCROSLYN Address, appraised value ($thousands), location, property size (acres), and age (Chapter 13)

GLENCOVE Address, appraised value ($thousands), property size (acres), and age in Glen Cove, New York (Chapter 13)

GOLFBALL Distance for designs 1, 2, 3, and 4 (Chapter 10)

GPIGMAT GMAT scores and GPA (Chapter 12)

GRADSURVEY ID number, gender, age (as of last birthday), graduate major (accounting, economics and finance, management, marketing/retailing, other, undecided), current graduate cumulative grade point average, undergraduate major (biological sciences, business, computers, engineering, other), undergraduate cumulative grade point average, current employment status (full-time, part-time, unemployed), number of different full-time jobs held in the past 10 years, expected salary upon completion of MBA ($thousands), amount spent for books and supplies this semester, satisfaction with student advising services on campus, type of computer owned, text messages per week, and wealth accumulated to feel rich (Chapters 1, 2, 3, 4, 6, 8, 10, and 11)

GRANULE Granule loss in Boston and Vermont shingles (Chapters 3, 8, 9, and 10)

HARNSWELL Day and diameter of cam rollers (in inches) (Chapter 14)

HOSPADM Day, number of admissions, mean processing time (in hours), range of processing times, and proportion of laboratory rework (over a 30-day period) (Chapter 14)

HOTEL1 Day, number of rooms studied, number of nonconforming rooms per day over a 28-day period, and proportion of nonconforming items (Chapter 14)

HOTEL2 Day and delivery time for subgroups of five luggage deliveries per day over a 28-day period (Chapter 14)

HOTELPRICES City and cost (in English pounds) of two-star, three-star, and four-star hotels (Chapters 2 and 3)

HOTELUK City and cost of a hotel room ($) (Chapter 3)

HOUSE1 Selling price ($thousands), assessed value ($thousands), type (new = 0, old = 1), and time period of sale for 30 houses (Chapters 12 and 13)

HOUSE2 Assessed value ($thousands), size of heating area (in thousands of square feet), and age (in years) for 15 houses (Chapters 12 and 13)

HOUSE3 Assessed value ($thousands), size (in thousands of square feet), and presence of a fireplace for 15 houses (Chapter 13)

ICECREAM Daily temperature (in degrees Fahrenheit) and sales ($thousands) for 21 days (Chapter 12)

INSURANCE Processing time in days for insurance policies (Chapters 3, 8, and 9)

INVOICE Number of invoices processed and amount of time (in hours) for 30 days (Chapter 12)

INVOICES Amount recorded (in dollars) from sales invoices (Chapters 8 and 9)

LARGEST BONDS Bond fund and one-year return of bond funds (Chapter 3)

LUGGAGE Delivery time (in minutes) for luggage in Wing A and Wing B of a hotel (Chapter 10)

MEASUREMENT Sample, in-line measurement, and analytical lab measurement (Chapter 10)

MEDREC Day, number of discharged patients, and number of records not processed for a 30-day period (Chapter 14)

MOISTURE Moisture content of Boston shingles and Vermont shingles (Chapter 9)

MOVIE Title, box office gross ($millions), and DVD revenue ($millions) (Chapter 2)

MOVIE ATTENDANCE Year and movie attendance (billions) (Chapter 2)

MOVIE SHARE Type of movie, number of movies, gross ($millions), and number of tickets (millions) (Chapter 2)

MOVIEGROSS Year and combined gross of movies ($millions) (Chapter 2)

MOVING Labor hours, cubic feet, number of large pieces of furniture, and availability of an elevator (Chapters 12 and 13)

MUTUAL FUNDS Category, objective, assets ($millions), fees, expense ratio, 2006 return, three-year return, five-year return, and risk (Chapter 2)

MYELOMA Patient, measurement before transplant, and measurement after transplant (Chapter 10)

NATURAL GAS Month, wellhead, price, and residential price (Chapter 2)

NBA2011 Team, number of wins, field goal (shots made) percentage (for team and opponent) (Chapter 13)

NBAVALUES Team, annual revenue ($millions), and value ($millions) for NBA franchises (Chapters 2, 3, and 12)

NEIGHBOR Selling price ($thousands), number of rooms, and neighborhood location (0 = east, 1 = west) (Chapter 13)

NEW HOME PRICES Year and mean price ($thousands) (Chapter 2)

OIL&GASOLINE Week, price of oil per barrel, and price of a gallon of gasoline ($) (Chapter 12)

OMNIPOWER Bars sold, price (cents), and promotion expenses ($) (Chapter 13)

ORDER Time in minutes to fill orders for a population of 200 (Chapter 8)

O-RING Flight number, temperature, and O-ring damage index (Chapter 12)

PALLET Weight of Boston shingles and weight of Vermont shingles (Chapters 2, 8, 9, and 10)

PARACHUTE Tensile strength of parachutes from suppliers 1, 2, 3, and 4; the sample means and the sample standard deviations for the four suppliers in rows 8 and 9 (Chapter 10)

PEN Gender, ad, and product rating (Chapter 10)

PERFORM Performance rating before and after motivational training (Chapter 10)

PETFOOD Shelf space (in feet), weekly sales ($), and aisle location (0 = back, 1 = front) (Chapters 12 and 13)

PHONE Time (in minutes) to clear telephone line problems and location (1 = I and 2 = II) (Chapter 10)

PIZZATIME Time period, delivery time for local restaurant, and delivery time for national chain (Chapter 10)

POTTERMOVIES Title, first weekend gross ($millions), U.S. gross ($millions), and worldwide gross ($millions) (Chapters 2, 3, and 12)

PROPERTYTAXES State and property taxes per capita ($) (Chapters 2, 3, and 6)

PROTEIN Type of food, calories (in grams), protein, percentage of calories from fat, percentage of calories from saturated fat, and cholesterol (mg) (Chapters 2 and 3)

PUMPKIN Circumference and weight of pumpkins (Chapter 12)

REDWOOD Height (ft.), breast height diameter (in.), and bark thickness (in.) (Chapters 12 and 13)

RENT Monthly rental cost (in dollars) and apartment size (in square footage) (Chapter 12)

RESTAURANTS Location, food rating, decor rating, service rating, summated rating, coded location (0 = city, 1 = suburban), and cost of a meal (Chapters 2, 3, 10, 12, and 13)

RETURN 2009 UNSTACKED Intermediate government return in 2009 and short-term corporate return in 2009 (Chapter 2)

RUDYBIRD Day, total cases sold, and cases of Rudybird sold (Chapter 14)

SEALANT Sample number, sealant strength for Boston shingles, and sealant strength for Vermont shingles (Chapter 14)

SHOPPING1 Product, Costco price ($), and store brand price ($) (Chapter 10)

SITE Store number, square footage (in thousands of square feet), and sales ($millions) (Chapter 12)

SOCCERVALUES 2011 Team, country, revenue ($millions), and value ($millions) (Chapter 12)

SPONGE Day, number of sponges produced, number of nonconforming sponges, and proportion of nonconforming sponges (Chapter 14)

SPORTING Sales ($), age, annual population growth, income ($), percentage with high school diploma, and percentage with college diploma (Chapter 12)

SPWATER Sample number and amount of magnesium (Chapter 14)

STANDBY Standby hours, total staff present, remote hours, Dubner hours, and labor hours (Chapter 13)

STARBUCKS Tear, viscosity, pressure, plate gap (Chapter 13)

STEEL Error in actual length and specified length (Chapters 2, 6, 8, and 9)

STOCK PERFORMANCE Decade and stock performance (%) (Chapter 2)

STOCKPRICES2010 Week, and closing weekly stock price for GE, Discovery, and Apple (Chapter 12)

STUDYTIME Gender and study time (Chapter 10)

SUV Miles per gallon for 2011 small SUVs (Chapter 6)

TAX Quarterly sales tax receipts ($thousands) (Chapter 3)

TEA3 Sample number and weight of tea bags in ounces (Chapter 14)

TEABAGS Weight of tea bags in ounces (Chapters 3, 8, and 9)

TELESPC Number of orders and number of corrections over 30 days (Chapter 14)

TENSILE Sample number and strength (Chapter 14)

THICKNESS Thickness, catalyst, pH, pressure, temperature, and voltage (Chapter 13)

TIMES Times to get ready (Chapter 3)

TRADE Days, number of undesirable trades, and total number of trades made over a 30-day period (Chapter 14)

TRANSMIT Day and number of errors in transmission (Chapter 14)

TRANSPORT Days and patient transport times (in minutes) (Chapter 14)

TRASHBAGS Weight required to break four brands of trash bags (Kroger, Glad, Hefty, Tuff Stuff) (Chapter 10)

TROUGH Width of trough (Chapters 3, 8, and 9)

UNDERGRADSURVEY ID number, gender, age (as of last birthday), class designation, major (accounting, computer information systems, economics and finance, international business, management, marketing, other, undecided) graduate school intention (yes, no, undecided), cumulative grade point average, current employment status, expected starting salary ($thousands), number of social networking sites registered for, satisfaction with student advisement services on campus, amount spent on books and supplies this semester, type of computer preferred (desktop, laptop, tablet/notebook/netbook), text messages per week, and wealth accumulated to feel rich (Chapters 1, 2, 3, 4, 6, 8, 10, and 11)

UTILITY Utilities charges ($) for 50 one-bedroom apartments (Chapter 6)

VB Time (in minutes) for nine students to write and run a Visual Basic program (Chapter 10)

VEGGIEBURGER Calories and fat in veggie burgers (Chapters 2 and 3)

WAIT Waiting times and seating times (in minutes) in a restaurant (Chapter 6)

WARECOST Distribution cost ($thousands), sales ($thousands), and number of orders (Chapters 12 and 13)

WAREHSE Day, units handled, and employee number (Chapter 14)

WONDERLIC School, average Wonderlic score of football players trying out for the NFL, and graduation rate (Chapters 2, 3, and 12)

Excel Guide Workbooks

Excel Guide workbooks contain model solutions that can be reused as templates for solving other problems.The *In-Depth Excel* instructions of the Excel Guides feature these workbooks and the workbooks also document many of the worksheets created by PHStat2. Worksheets from these workbooks are the source of many of the illustrations of Excel results shown in this book.

Workbooks are stored in the **.xls** format, compatible with all Excel versions. Most contain a **COMPUTE worksheet** (often shown in this book) that presents results as well as a **COMPUTE_FORMULAS worksheet** that allows for the easy inspection of all worksheet formulas used in the worksheet.

The Excel Guide workbooks for this book are:

Bayes
Binomial
Boxplot
Chapter 2
Chi-Square
Chi-Square Worksheets
CIE Proportion
CIE sigma known
CIE sigma unknown
Correlation
Covariance
Descriptive
Discrete Random Variable
F Two Variances
Levene
Multiple Regression
Normal
NPP
One-Way ANOVA
p Chart
Paired T
Poisson
Pooled-Variance T
Probabilities
Quartiles
R and XBar Chart
Random
Sample Size Mean
Sample Size Proportion
SDS
Separate-Variance T
Simple Linear Regression
StackedAndUnstacked

T Mean
Variability
Z Mean
Z Proportion
Z Two Proportions

PDF Files

PDF files use the Portable Document Format that can be viewed in most web browsers and PDF utility programs, such as Adobe Reader, the free program available for download at **get.adobe.com/reader/**. Both the Digital Case files and the online topics files use this format.

Files for the Digital Case The set of PDF files that support the end-of-chapter Digital Cases. Some of the Digital Case PDF files contain attached or embedded Excel and Minitab files for use with particular case questions. Some Digital Cases use interactive PDF files that require Adobe Reader, version X(10) or later, for full functionality.

Online Topics PDF files that contain additional textbook material. **Binomial.pdf** and **Poisson.pdf**, contain the reference tables associated these discrete probability distributions, discussed in Chapter 5. **Chapter14.pdf** contains the full text of Chapter 14, "Statistical Applications in Quality Management."

Other Downloadable Files

Managing Ashland MultiComm Services Running Case Files The set of data files that support the "Managing Ashland MultiComm Services" running case. These data files are also included in the Data Files set and are included in the alphabetical list on previous pages.

Visual Explorations This Excel add-in is packaged as a self-extracting zip file that expands to three files. The three files can be stored in the folder of your choice, but all three files must be present together in the same folder for the add-in workbook to function properly.

PHStat2 readme file and PHStat2 setup file Files that allow you to use the PHStat2 add-in with Microsoft Windows-based Excel 2003, 2007 or 2010. The readme file, in PDF format, should be downloaded and read first to allow you to review all of the technical and setup requirements for using PHStat2. The setup program, a self-extracting **.exe** file, sets up and installs PHStat2 on your Microsoft Windows system and must be run using a Windows user account that has administrator privileges.

Sections D.2 and D.3 in Appendix D review the basics of installing PHStat2 and configuring Excel for use with PHStat2. The PHStat2 FAQs in Appendix G provide answers to frequently asked questions about PHStat2.

APPENDIX D Software Configuration Details

D.1 Checking for and Applying Updates

Excel

To check for and apply Excel updates, your system must be connected to the Internet. You can check and apply updates using one of two methods. If Internet Explorer is the default web browser on your system, use the Excel "check for updates" feature. In Excel 2010, select **File ➔ Help ➔ Check for Updates** and follow the instructions that appear on the web page that is displayed. In Excel 2007, click the **Office Button** and then **Excel Options** (at the bottom of the Office Button menu window). In the Excel options dialog box, click **Resources** in the left pane and then in the right pane click **Check for Updates** and follow the instructions that appear on the web page that is displayed.

If the first method fails for any reason, you can manually download Excel and Microsoft Office updates by opening a web browser and going to **office.microsoft.com/officeupdate**. On the web page that is displayed, you can find download links arranged by popularity as well as by product version. If you use this second method, you need to know the exact version and status of your copy of Excel. In Excel 2010, select **File ➔ Help** and note the information under the heading "About Microsoft Excel." In Excel 2007, click the **Office Button** and then **Excel Options**. In the Excel options dialog box, click **Resources** in the left pane and then in the right pane note the detail line under the heading "about Microsoft Office Excel 2007." The numbers and codes that follow the words "Microsoft Office Excel" indicate the version number and updates already applied.

If you use Mac Excel, select **Help ➔ Check for Updates** to begin Microsoft AutoUpdate for Mac, similar to Microsoft Update, described above, for checking and applying updates.

Special Notes About the Windows Update Service If you use a Microsoft Windows–based system and have previously turned on the Windows Update service, your system has not necessarily downloaded and applied all Excel updates. If you use Windows Update, you can upgrade for free to the Microsoft Update service that searches for and downloads updates for all Microsoft products, including Excel and Office. (You can learn more about the Microsoft Update service by visiting **www.microsoft.com/security/updates/mu.aspx**.)

Minitab

To check for and apply Minitab updates, your system must be connected to the Internet. Select **Help ➔ Check for Updates**. Follow directions, if any, that appear in the Minitab Software Update Manager dialog box. If there are no new updates, you will see a dialog box that states "There are no updates available." Click **OK** in that dialog box and then click **Cancel** in the Update Manager dialog box to continue with your Minitab session.

D.2 Concise Instructions for Installing PHStat2

If your system can run the Microsoft Windows–based Excel 2003, Excel 2007, or Excel 2010, you can download, install, and use PHStat2. Before using PHStat2:

- Check for and apply all Excel updates by using the instructions in Section D.1.
- Download and read the PHStat2 readme file for the latest information about PHStat2 (see Appendix Section C.1).

- Download the PHStat2 setup program (see Appendix Section C.3).
- Run the PHStat2 setup program to install PHStat2 on your system, taking note of the technical requirements listed in the PHStat2 readme file.
- Configure Excel to use PHStat2 (see Appendix Section D.3).

The PHStat2 setup program copies the PHStat2 files to your system and adds entries in the Windows registry file on your system. Run the setup program only after first logging on to Windows using a user account that has administrator privileges. (Running the setup program with a Windows user account that does not include these privileges will prevent the setup program from properly installing PHStat2.)

If your system runs Windows Vista, Windows 7, or certain third-party security programs, you may see messages asking you to "permit" or "allow" specific system operations as the setup program executes. If you do not give the setup program the necessary permissions, PHStat2 will *not* be properly installed on your computer.

After the setup completes, check the installation by opening PHStat2. If the installation ran properly, Excel will display a PHStat menu in the Add-Ins tab of the Office Ribbon (Excel 2007 or Excel 2010) or the Excel menu bar (Excel 2003). If you have skipped checking for and applying necessary Excel updates, or if some of the updates were unable to be applied, when you first attempt to use PHStat2, you may see a "Compile Error" message that talks about a "hidden module." If this occurs, repeat the process of checking for and applying updates to Excel. (If the bandwidth of the Internet connection is limited, you may need to use another connection.)

As you use PHStat, check the Pearson Education PHStat website, **www.pearsonhighered.com/phstat**. For more information about PHStat without going online, read Appendix Section G.1.

D.3 Configuring Excel for PHStat2 Usage

To configure Excel security settings for PHStat2 usage:

1. In Excel 2010, select **File → Options**. In Excel 2007, click the Office Button and then click **Excel Options** (at the bottom of the Office Button menu window).

In the Excel Options dialog box:

2. Click **Trust Center** in the left pane and then click **Trust Center Settings** in the right pane (see the top of Figure D.1).

In the Trust Center dialog box:

3. Click **Add-ins** in the next left pane, and in the Add-ins right pane clear all of the checkboxes (see the bottom left of Figure D.1).
4. Click **Macro Settings** in the left pane, and in the Macro Settings right pane click **Disable all macros with notification** and check **Trust access to the VBA object model** (see the bottom right of Figure D.1).
5. Click **OK** to close the Trust Center dialog box.

Back in the Excel Options dialog box:

6. Click **OK** to finish.

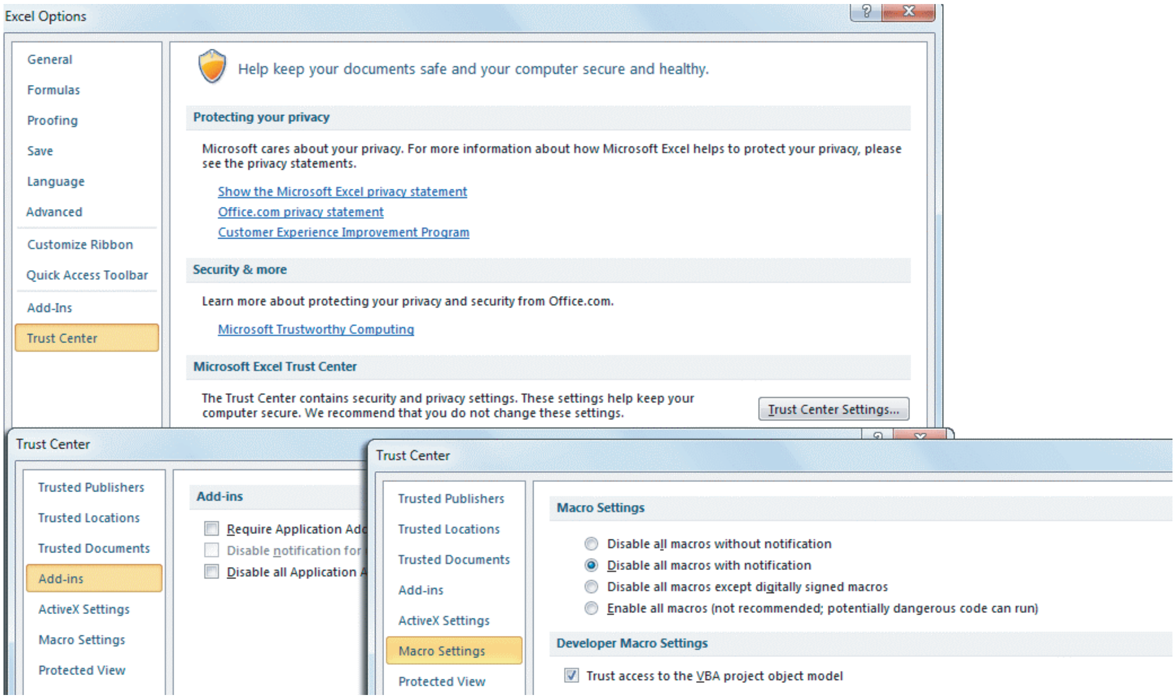


FIGURE D.1

Configuring Excel security settings

On some systems that have stringent security settings, you might need to modify step 5. For such systems, in step 5, click **Trusted Locations** in the left pane and then, in the Trusted Locations right pane, click **Add new location** to add the folder path to the PHStat2 add-in (typically C:\Program Files\PHStat2) and then click **OK**.

When you open PHStat2, Excel will display a Microsoft Excel Security Notice dialog box (shown below). Click **Enable Macros** to enable PHStat2 to open and function.

D.4 Using the Visual Explorations Add-in Workbook

To use the Visual Explorations add-in workbook, first download the set of three files that comprise Visual Explorations from this book's companion website (see Appendix C). Place the three files together in a folder of your choosing. Next, use the Section D.3 instructions for configuring Excel for PHStat2 usage. Then open the **Visual Explorations.xla** file in Excel and use the VisualExplorations menu in the **Add-Ins** tab to select individual procedures.

D.5 Checking for the Presence of the Analysis ToolPak

To check for the presence of the Analysis ToolPak add-in (needed only if you will be using the *Analysis ToolPak* Excel Guide instructions):

1. In Excel 2010, select **File ➔ Options**. In Excel 2007, click the **Office Button** and then click **Excel Options** (at the bottom of the Office Button menu window).

In the Excel Options dialog box:

2. Click **Add-Ins** in the left pane and look for the entry **Analysis ToolPak** in the right pane, under **Active Application Add-ins**.
3. If the entry appears, click **OK**.

If the entry does not appear in the **Active Application Add-ins** list, click **Go**. In the Add-Ins dialog box, check **Analysis ToolPak** in the **Add-Ins available** list and click **OK**. If Analysis ToolPak does not appear in the list, rerun the Microsoft Office setup program to install this component.

The Analysis ToolPak add-in is not included and is not available for Mac Excel 2008 but is included in other versions of Mac Excel.

APPENDIX E Tables

TABLE E.1
Table of Random Numbers

	Column							
Row	00000 12345	00001 67890	11111 12345	11112 67890	22222 12345	22223 67890	33333 12345	33334 67890
01	49280	88924	35779	00283	81163	07275	89863	02348
02	61870	41657	07468	08612	98083	97349	20775	45091
03	43898	65923	25078	86129	78496	97653	91550	08078
04	62993	93912	30454	84598	56095	20664	12872	64647
05	33850	58555	51438	85507	71865	79488	76783	31708
06	97340	03364	88472	04334	63919	36394	11095	92470
07	70543	29776	10087	10072	55980	64688	68239	20461
08	89382	93809	00796	95945	34101	81277	66090	88872
09	37818	72142	67140	50785	22380	16703	53362	44940
10	60430	22834	14130	96593	23298	56203	92671	15925
11	82975	66158	84731	19436	55790	69229	28661	13675
12	30987	71938	40355	54324	08401	26299	49420	59208
13	55700	24586	93247	32596	11865	63397	44251	43189
14	14756	23997	78643	75912	83832	32768	18928	57070
15	32166	53251	70654	92827	63491	04233	33825	69662
16	23236	73751	31888	81718	06546	83246	47651	04877
17	45794	26926	15130	82455	78305	55058	52551	47182
18	09893	20505	14225	68514	47427	56788	96297	78822
19	54382	74598	91499	14523	68479	27686	46162	83554
20	94750	89923	37089	20048	80336	94598	26940	36858
21	70297	34135	53140	33340	42050	82341	44104	82949
22	85157	47954	32979	26575	57600	40881	12250	73742
23	11100	02340	12860	74697	96644	89439	28707	25815
24	36871	50775	30592	57143	17381	68856	25853	35041
25	23913	48357	63308	16090	51690	54607	72407	55538
26	79348	36085	27973	65157	07456	22255	25626	57054
27	92074	54641	53673	54421	18130	60103	69593	49464
28	06873	21440	75593	41373	49502	17972	82578	16364
29	12478	37622	99659	31065	83613	69889	58869	29571
30	57175	55564	65411	42547	70457	03426	72937	83792
31	91616	11075	80103	07831	59309	13276	26710	73000
32	78025	73539	14621	39044	47450	03197	12787	47709
33	27587	67228	80145	10175	12822	86687	65530	49325
34	16690	20427	04251	64477	73709	73945	92396	68263
35	70183	58065	65489	31833	82093	16747	10386	59293
36	90730	35385	15679	99742	50866	78028	75573	67257
37	10934	93242	13431	24590	02770	48582	00906	58595
38	82462	30166	79613	47416	13389	80268	05085	96666
39	27463	10433	07606	16285	93699	60912	94532	95632
40	02979	52997	09079	92709	90110	47506	53693	49892
41	46888	69929	75233	52507	32097	37594	10067	67327
42	53638	83161	08289	12639	08141	12640	28437	09268
43	82433	61427	17239	89160	19666	08814	37841	12847
44	35766	31672	50082	22795	66948	65581	84393	15890
45	10853	42581	08792	13257	61973	24450	52351	16602
46	20341	27398	72906	63955	17276	10646	74692	48438
47	54458	90542	77563	51839	52901	53355	83281	19177
48	26337	66530	16687	35179	46560	00123	44546	79896
49	34314	23729	85264	05575	96855	23820	11091	79821
50	28603	10708	68933	34189	92166	15181	66628	58599
51	66194	28926	99547	16625	45515	67953	12108	57846
52	78240	43195	24837	32511	70880	22070	52622	61881
53	00833	88000	67299	68215	11274	55624	32991	17436
54	12111	86683	61270	58036	64192	90611	15145	01748
55	47189	99951	05755	03834	43782	90599	40282	51417
56	76396	72486	62423	27618	84184	78922	73561	52818
57	46409	17469	32483	09083	76175	19985	26309	91536

TABLE E.1

Table of Random Numbers (*continued*)

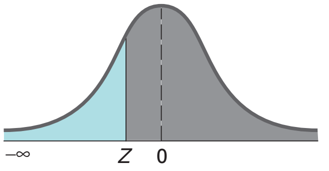
	Column							
Row	**00000 12345**	**00001 67890**	**11111 12345**	**11112 67890**	**22222 12345**	**22223 67890**	**33333 12345**	**33334 67890**
58	74626	22111	87286	46772	42243	68046	44250	42439
59	34450	81974	93723	49023	58432	67083	36876	93391
60	36327	72135	33005	28701	34710	49359	50693	89311
61	74185	77536	84825	09934	99103	09325	67389	45869
62	12296	41623	62873	37943	25584	09609	63360	47270
63	90822	60280	88925	99610	42772	60561	76873	04117
64	72121	79152	96591	90305	10189	79778	68016	13747
65	95268	41377	25684	08151	61816	58555	54305	86189
66	92603	09091	75884	93424	72586	88903	30061	14457
67	18813	90291	05275	01223	79607	95426	34900	09778
68	38840	26903	28624	67157	51986	42865	14508	49315
69	05959	33836	53758	16562	41081	38012	41230	20528
70	85141	21155	99212	32685	51403	31926	69813	58781
71	75047	59643	31074	38172	03718	32119	69506	67143
72	30752	95260	68032	62871	58781	34143	68790	69766
73	22986	82575	42187	62295	84295	30634	66562	31442
74	99439	86692	90348	66036	48399	73451	26698	39437
75	20389	93029	11881	71685	65452	89047	63669	02656
76	39249	05173	68256	36359	20250	68686	05947	09335
77	96777	33605	29481	20063	09398	01843	35139	61344
78	04860	32918	10798	50492	52655	33359	94713	28393
79	41613	42375	00403	03656	77580	87772	86877	57085
80	17930	00794	53836	53692	67135	98102	61912	11246
81	24649	31845	25736	75231	83808	98917	93829	99430
82	79899	34061	54308	59358	56462	58166	97302	86828
83	76801	49594	81002	30397	52728	15101	72070	33706
84	36239	63636	38140	65731	39788	06872	38971	53363
85	07392	64449	17886	63632	53995	17574	22247	62607
86	67133	04181	33874	98835	67453	59734	76381	63455
87	77759	31504	32832	70861	15152	29733	75371	39174
88	85992	72268	42920	20810	29361	51423	90306	73574
89	79553	75952	54116	65553	47139	60579	09165	85490
90	41101	17336	48951	53674	17880	45260	08575	49321
91	36191	17095	32123	91576	84221	78902	82010	30847
92	62329	63898	23268	74283	26091	68409	69704	82267
93	14751	13151	93115	01437	56945	89661	67680	79790
94	48462	59278	44185	29616	76537	19589	83139	28454
95	29435	88105	59651	44391	74588	55114	80834	85686
96	28340	29285	12965	14821	80425	16602	44653	70467
97	02167	58940	27149	80242	10587	79786	34959	75339
98	17864	00991	39557	54981	23588	81914	37609	13128
99	79675	80605	60059	35862	00254	36546	21545	78179
100	72335	82037	92003	34100	29879	46613	89720	13274

Source: Partially extracted from the Rand Corporation, *A Million Random Digits with 100,000 Normal Deviates* (Glencoe, IL, The Free Press, 1955).

TABLE E.2

The Cumulative Standardized Normal Distribution

Entry represents area under the cumulative standardized normal distribution from $-\infty$ to Z



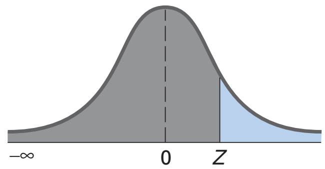
Cumulative Probabilities

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
−6.0	0.000000001									
−5.5	0.000000019									
−5.0	0.000000287									
−4.5	0.000003398									
−4.0	0.000031671									
−3.9	0.00005	0.00005	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00003	0.00003
−3.8	0.00007	0.00007	0.00007	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00005
−3.7	0.00011	0.00010	0.00010	0.00010	0.00009	0.00009	0.00008	0.00008	0.00008	0.00008
−3.6	0.00016	0.00015	0.00015	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00011
−3.5	0.00023	0.00022	0.00022	0.00021	0.00020	0.00019	0.00019	0.00018	0.00017	0.00017
−3.4	0.00034	0.00032	0.00031	0.00030	0.00029	0.00028	0.00027	0.00026	0.00025	0.00024
−3.3	0.00048	0.00047	0.00045	0.00043	0.00042	0.00040	0.00039	0.00038	0.00036	0.00035
−3.2	0.00069	0.00066	0.00064	0.00062	0.00060	0.00058	0.00056	0.00054	0.00052	0.00050
−3.1	0.00097	0.00094	0.00090	0.00087	0.00084	0.00082	0.00079	0.00076	0.00074	0.00071
−3.0	0.00135	0.00131	0.00126	0.00122	0.00118	0.00114	0.00111	0.00107	0.00103	0.00100
−2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
−2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
−2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
−2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
−2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
−2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
−2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
−2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
−2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
−2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
−1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
−1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
−1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
−1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
−1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
−1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
−1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
−1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
−1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
−1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
−0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
−0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
−0.7	0.2420	0.2388	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
−0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2482	0.2451
−0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
−0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
−0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
−0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
−0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
−0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641

TABLE E.2

The Cumulative Standardized Normal Distribution (*continued*)

Entry represents area under the cumulative standardized normal distribution from $-\infty$ to Z

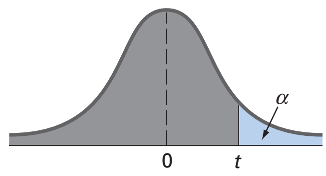


Cumulative Probabilities

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7518	0.7549
0.7	0.7580	0.7612	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.99865	0.99869	0.99874	0.99878	0.99882	0.99886	0.99889	0.99893	0.99897	0.99900
3.1	0.99903	0.99906	0.99910	0.99913	0.99916	0.99918	0.99921	0.99924	0.99926	0.99929
3.2	0.99931	0.99934	0.99936	0.99938	0.99940	0.99942	0.99944	0.99946	0.99948	0.99950
3.3	0.99952	0.99953	0.99955	0.99957	0.99958	0.99960	0.99961	0.99962	0.99964	0.99965
3.4	0.99966	0.99968	0.99969	0.99970	0.99971	0.99972	0.99973	0.99974	0.99975	0.99976
3.5	0.99977	0.99978	0.99978	0.99979	0.99980	0.99981	0.99981	0.99982	0.99983	0.99983
3.6	0.99984	0.99985	0.99985	0.99986	0.99986	0.99987	0.99987	0.99988	0.99988	0.99989
3.7	0.99989	0.99990	0.99990	0.99990	0.99991	0.99991	0.99992	0.99992	0.99992	0.99992
3.8	0.99993	0.99993	0.99993	0.99994	0.99994	0.99994	0.99994	0.99995	0.99995	0.99995
3.9	0.99995	0.99995	0.99996	0.99996	0.99996	0.99996	0.99996	0.99996	0.99997	0.99997
4.0	0.999968329									
4.5	0.999996602									
5.0	0.999999713									
5.5	0.999999981									
6.0	0.999999999									

TABLE E.3

Critical Values of *t*



For a particular number of degrees of freedom, entry represents the critical value of t corresponding to the cumulative probability $(1 - \alpha)$ *and a specified upper-tail area* (α).

	Cumulative Probabilities					
	0.75	**0.90**	**0.95**	**0.975**	**0.99**	**0.995**
	Upper-Tail Areas					
Degrees of Freedom	**0.25**	**0.10**	**0.05**	**0.025**	**0.01**	**0.005**
1	1.0000	3.0777	6.3138	12.7062	31.8207	63.6574
2	0.8165	1.8856	2.9200	4.3027	6.9646	9.9248
3	0.7649	1.6377	2.3534	3.1824	4.5407	5.8409
4	0.7407	1.5332	2.1318	2.7764	3.7469	4.6041
5	0.7267	1.4759	2.0150	2.5706	3.3649	4.0322
6	0.7176	1.4398	1.9432	2.4469	3.1427	3.7074
7	0.7111	1.4149	1.8946	2.3646	2.9980	3.4995
8	0.7064	1.3968	1.8595	2.3060	2.8965	3.3554
9	0.7027	1.3830	1.8331	2.2622	2.8214	3.2498
10	0.6998	1.3722	1.8125	2.2281	2.7638	3.1693
11	0.6974	1.3634	1.7959	2.2010	2.7181	3.1058
12	0.6955	1.3562	1.7823	2.1788	2.6810	3.0545
13	0.6938	1.3502	1.7709	2.1604	2.6503	3.0123
14	0.6924	1.3450	1.7613	2.1448	2.6245	2.9768
15	0.6912	1.3406	1.7531	2.1315	2.6025	2.9467
16	0.6901	1.3368	1.7459	2.1199	2.5835	2.9208
17	0.6892	1.3334	1.7396	2.1098	2.5669	2.8982
18	0.6884	1.3304	1.7341	2.1009	2.5524	2.8784
19	0.6876	1.3277	1.7291	2.0930	2.5395	2.8609
20	0.6870	1.3253	1.7247	2.0860	2.5280	2.8453
21	0.6864	1.3232	1.7207	2.0796	2.5177	2.8314
22	0.6858	1.3212	1.7171	2.0739	2.5083	2.8188
23	0.6853	1.3195	1.7139	2.0687	2.4999	2.8073
24	0.6848	1.3178	1.7109	2.0639	2.4922	2.7969
25	0.6844	1.3163	1.7081	2.0595	2.4851	2.7874
26	0.6840	1.3150	1.7056	2.0555	2.4786	2.7787
27	0.6837	1.3137	1.7033	2.0518	2.4727	2.7707
28	0.6834	1.3125	1.7011	2.0484	2.4671	2.7633
29	0.6830	1.3114	1.6991	2.0452	2.4620	2.7564
30	0.6828	1.3104	1.6973	2.0423	2.4573	2.7500
31	0.6825	1.3095	1.6955	2.0395	2.4528	2.7440
32	0.6822	1.3086	1.6939	2.0369	2.4487	2.7385
33	0.6820	1.3077	1.6924	2.0345	2.4448	2.7333
34	0.6818	1.3070	1.6909	2.0322	2.4411	2.7284
35	0.6816	1.3062	1.6896	2.0301	2.4377	2.7238
36	0.6814	1.3055	1.6883	2.0281	2.4345	2.7195
37	0.6812	1.3049	1.6871	2.0262	2.4314	2.7154
38	0.6810	1.3042	1.6860	2.0244	2.4286	2.7116
39	0.6808	1.3036	1.6849	2.0227	2.4258	2.7079
40	0.6807	1.3031	1.6839	2.0211	2.4233	2.7045
41	0.6805	1.3025	1.6829	2.0195	2.4208	2.7012
42	0.6804	1.3020	1.6820	2.0181	2.4185	2.6981
43	0.6802	1.3016	1.6811	2.0167	2.4163	2.6951
44	0.6801	1.3011	1.6802	2.0154	2.4141	2.6923
45	0.6800	1.3006	1.6794	2.0141	2.4121	2.6896
46	0.6799	1.3002	1.6787	2.0129	2.4102	2.6870
47	0.6797	1.2998	1.6779	2.0117	2.4083	2.6846
48	0.6796	1.2994	1.6772	2.0106	2.4066	2.6822

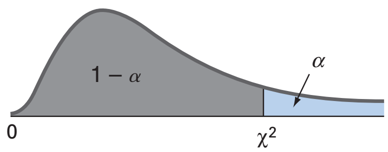
TABLE E.3
Critical Values of t (*continued*)

Degrees of Freedom	Cumulative Probabilities					
	0.75	0.90	0.95	0.975	0.99	0.995
	Upper-Tail Areas					
	0.25	0.10	0.05	0.025	0.01	0.005
49	0.6795	1.2991	1.6766	2.0096	2.4049	2.6800
50	0.6794	1.2987	1.6759	2.0086	2.4033	2.6778
51	0.6793	1.2984	1.6753	2.0076	2.4017	2.6757
52	0.6792	1.2980	1.6747	2.0066	2.4002	2.6737
53	0.6791	1.2977	1.6741	2.0057	2.3988	2.6718
54	0.6791	1.2974	1.6736	2.0049	2.3974	2.6700
55	0.6790	1.2971	1.6730	2.0040	2.3961	2.6682
56	0.6789	1.2969	1.6725	2.0032	2.3948	2.6665
57	0.6788	1.2966	1.6720	2.0025	2.3936	2.6649
58	0.6787	1.2963	1.6716	2.0017	2.3924	2.6633
59	0.6787	1.2961	1.6711	2.0010	2.3912	2.6618
60	0.6786	1.2958	1.6706	2.0003	2.3901	2.6603
61	0.6785	1.2956	1.6702	1.9996	2.3890	2.6589
62	0.6785	1.2954	1.6698	1.9990	2.3880	2.6575
63	0.6784	1.2951	1.6694	1.9983	2.3870	2.6561
64	0.6783	1.2949	1.6690	1.9977	2.3860	2.6549
65	0.6783	1.2947	1.6686	1.9971	2.3851	2.6536
66	0.6782	1.2945	1.6683	1.9966	2.3842	2.6524
67	0.6782	1.2943	1.6679	1.9960	2.3833	2.6512
68	0.6781	1.2941	1.6676	1.9955	2.3824	2.6501
69	0.6781	1.2939	1.6672	1.9949	2.3816	2.6490
70	0.6780	1.2938	1.6669	1.9944	2.3808	2.6479
71	0.6780	1.2936	1.6666	1.9939	2.3800	2.6469
72	0.6779	1.2934	1.6663	1.9935	2.3793	2.6459
73	0.6779	1.2933	1.6660	1.9930	2.3785	2.6449
74	0.6778	1.2931	1.6657	1.9925	2.3778	2.6439
75	0.6778	1.2929	1.6654	1.9921	2.3771	2.6430
76	0.6777	1.2928	1.6652	1.9917	2.3764	2.6421
77	0.6777	1.2926	1.6649	1.9913	2.3758	2.6412
78	0.6776	1.2925	1.6646	1.9908	2.3751	2.6403
79	0.6776	1.2924	1.6644	1.9905	2.3745	2.6395
80	0.6776	1.2922	1.6641	1.9901	2.3739	2.6387
81	0.6775	1.2921	1.6639	1.9897	2.3733	2.6379
82	0.6775	1.2920	1.6636	1.9893	2.3727	2.6371
83	0.6775	1.2918	1.6634	1.9890	2.3721	2.6364
84	0.6774	1.2917	1.6632	1.9886	2.3716	2.6356
85	0.6774	1.2916	1.6630	1.9883	2.3710	2.6349
86	0.6774	1.2915	1.6628	1.9879	2.3705	2.6342
87	0.6773	1.2914	1.6626	1.9876	2.3700	2.6335
88	0.6773	1.2912	1.6624	1.9873	2.3695	2.6329
89	0.6773	1.2911	1.6622	1.9870	2.3690	2.6322
90	0.6772	1.2910	1.6620	1.9867	2.3685	2.6316
91	0.6772	1.2909	1.6618	1.9864	2.3680	2.6309
92	0.6772	1.2908	1.6616	1.9861	2.3676	2.6303
93	0.6771	1.2907	1.6614	1.9858	2.3671	2.6297
94	0.6771	1.2906	1.6612	1.9855	2.3667	2.6291
95	0.6771	1.2905	1.6611	1.9853	2.3662	2.6286
96	0.6771	1.2904	1.6609	1.9850	2.3658	2.6280
97	0.6770	1.2903	1.6607	1.9847	2.3654	2.6275
98	0.6770	1.2902	1.6606	1.9845	2.3650	2.6269
99	0.6770	1.2902	1.6604	1.9842	2.3646	2.6264
100	0.6770	1.2901	1.6602	1.9840	2.3642	2.6259
110	0.6767	1.2893	1.6588	1.9818	2.3607	2.6213
120	0.6765	1.2886	1.6577	1.9799	2.3578	2.6174
∞	0.6745	1.2816	1.6449	1.9600	2.3263	2.5758

TABLE E.4

Critical Values of χ^2

For a particular number of degrees of freedom, entry represents the critical value of χ^2 corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).

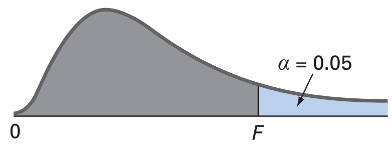


	Cumulative Probabilities											
	0.005	0.01	0.025	0.05	0.10	0.25	0.75	0.90	0.95	0.975	0.99	0.995
	Upper-Tail Areas (α)											
Degrees of Freedom	0.995	0.99	0.975	0.95	0.90	0.75	0.25	0.10	0.05	0.025	0.01	0.005
1			0.001	0.004	0.016	0.102	1.323	2.706	3.841	5.024	6.635	7.879
2	0.010	0.020	0.051	0.103	0.211	0.575	2.773	4.605	5.991	7.378	9.210	10.597
3	0.072	0.115	0.216	0.352	0.584	1.213	4.108	6.251	7.815	9.348	11.345	12.838
4	0.207	0.297	0.484	0.711	1.064	1.923	5.385	7.779	9.488	11.143	13.277	14.860
5	0.412	0.554	0.831	1.145	1.610	2.675	6.626	9.236	11.071	12.833	15.086	16.750
6	0.676	0.872	1.237	1.635	2.204	3.455	7.841	10.645	12.592	14.449	16.812	18.548
7	0.989	1.239	1.690	2.167	2.833	4.255	9.037	12.017	14.067	16.013	18.475	20.278
8	1.344	1.646	2.180	2.733	3.490	5.071	10.219	13.362	15.507	17.535	20.090	21.955
9	1.735	2.088	2.700	3.325	4.168	5.899	11.389	14.684	16.919	19.023	21.666	23.589
10	2.156	2.558	3.247	3.940	4.865	6.737	12.549	15.987	18.307	20.483	23.209	25.188
11	2.603	3.053	3.816	4.575	5.578	7.584	13.701	17.275	19.675	21.920	24.725	26.757
12	3.074	3.571	4.404	5.226	6.304	8.438	14.845	18.549	21.026	23.337	26.217	28.299
13	3.565	4.107	5.009	5.892	7.042	9.299	15.984	19.812	22.362	24.736	27.688	29.819
14	4.075	4.660	5.629	6.571	7.790	10.165	17.117	21.064	23.685	26.119	29.141	31.319
15	4.601	5.229	6.262	7.261	8.547	11.037	18.245	22.307	24.996	27.488	30.578	32.801
16	5.142	5.812	6.908	7.962	9.312	11.912	19.369	23.542	26.296	28.845	32.000	34.267
17	5.697	6.408	7.564	8.672	10.085	12.792	20.489	24.769	27.587	30.191	33.409	35.718
18	6.265	7.015	8.231	9.390	10.865	13.675	21.605	25.989	28.869	31.526	34.805	37.156
19	6.844	7.633	8.907	10.117	11.651	14.562	22.718	27.204	30.144	32.852	36.191	38.582
20	7.434	8.260	9.591	10.851	12.443	15.452	23.828	28.412	31.410	34.170	37.566	39.997
21	8.034	8.897	10.283	11.591	13.240	16.344	24.935	29.615	32.671	35.479	38.932	41.401
22	8.643	9.542	10.982	12.338	14.042	17.240	26.039	30.813	33.924	36.781	40.289	42.796
23	9.260	10.196	11.689	13.091	14.848	18.137	27.141	32.007	35.172	38.076	41.638	44.181
24	9.886	10.856	12.401	13.848	15.659	19.037	28.241	33.196	36.415	39.364	42.980	45.559
25	10.520	11.524	13.120	14.611	16.473	19.939	29.339	34.382	37.652	40.646	44.314	46.928
26	11.160	12.198	13.844	15.379	17.292	20.843	30.435	35.563	38.885	41.923	45.642	48.290
27	11.808	12.879	14.573	16.151	18.114	21.749	31.528	36.741	40.113	43.194	46.963	49.645
28	12.461	13.565	15.308	16.928	18.939	22.657	32.620	37.916	41.337	44.461	48.278	50.993
29	13.121	14.257	16.047	17.708	19.768	23.567	33.711	39.087	42.557	45.722	49.588	52.336
30	13.787	14.954	16.791	18.493	20.599	24.478	34.800	40.256	43.773	46.979	50.892	53.672

For larger values of degrees of freedom (df) the expression $Z = \sqrt{2\chi^2} - \sqrt{2(df) - 1}$ may be used and the resulting upper-tail area can be found from the cumulative standardized normal distribution (Table E.2).

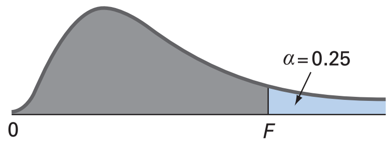
TABLE E.5

Critical Values of F



For a particular combination of numerator and denominator degrees of freedom, entry represents the critical values of F corresponding to the cumulative probability $(1 - \alpha)$ and a specified upper-tail area (α).

Cumulative Probabilities = 0.95																			
Upper-Tail Areas = 0.05																			
Numerator, df_1																			
Denominator, df_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	161.40	199.50	215.70	224.60	230.20	234.00	236.80	238.90	240.50	241.90	243.90	245.90	248.00	249.10	250.10	251.10	252.20	253.30	254.30
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.91	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

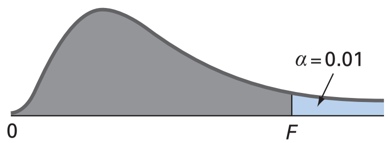


Denominator, df_2	Numerator, df_1: 1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
Cumulative Probabilities = 0.975																			
Upper-Tail Areas = 0.025																			
1	647.80	799.50	864.20	899.60	921.80	937.10	948.20	956.70	963.30	968.60	976.70	984.90	993.10	997.20	1,001.00	1,006.00	1,010.00	1,014.00	1,018.00
2	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.39	39.39	39.40	39.41	39.43	39.45	39.46	39.46	39.47	39.48	39.49	39.50
3	17.44	16.04	15.44	15.10	14.88	14.73	14.62	14.54	14.47	14.42	14.34	14.25	14.17	14.12	14.08	14.04	13.99	13.95	13.90
4	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98	8.90	8.84	8.75	8.66	8.56	8.51	8.46	8.41	8.36	8.31	8.26
5	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76	6.68	6.62	6.52	6.43	6.33	6.28	6.23	6.18	6.12	6.07	6.02
6	8.81	7.26	6.60	6.23	5.99	5.82	5.70	5.60	5.52	5.46	5.37	5.27	5.17	5.12	5.07	5.01	4.96	4.90	4.85
7	8.07	6.54	5.89	5.52	5.29	5.12	4.99	4.90	4.82	4.76	4.67	4.57	4.47	4.42	4.36	4.31	4.25	4.20	4.14
8	7.57	6.06	5.42	5.05	4.82	4.65	4.53	4.43	4.36	4.30	4.20	4.10	4.00	3.95	3.89	3.84	3.78	3.73	3.67
9	7.21	5.71	5.08	4.72	4.48	4.32	4.20	4.10	4.03	3.96	3.87	3.77	3.67	3.61	3.56	3.51	3.45	3.39	3.33
10	6.94	5.46	4.83	4.47	4.24	4.07	3.95	3.85	3.78	3.72	3.62	3.52	3.42	3.37	3.31	3.26	3.20	3.14	3.08
11	6.72	5.26	4.63	4.28	4.04	3.88	3.76	3.66	3.59	3.53	3.43	3.33	3.23	3.17	3.12	3.06	3.00	2.94	2.88
12	6.55	5.10	4.47	4.12	3.89	3.73	3.61	3.51	3.44	3.37	3.28	3.18	3.07	3.02	2.96	2.91	2.85	2.79	2.72
13	6.41	4.97	4.35	4.00	3.77	3.60	3.48	3.39	3.31	3.25	3.15	3.05	2.95	2.89	2.84	2.78	2.72	2.66	2.60
14	6.30	4.86	4.24	3.89	3.66	3.50	3.38	3.29	3.21	3.15	3.05	2.95	2.84	2.79	2.73	2.67	2.61	2.55	2.49
15	6.20	4.77	4.15	3.80	3.58	3.41	3.29	3.20	3.12	3.06	2.96	2.86	2.76	2.70	2.64	2.59	2.52	2.46	2.40
16	6.12	4.69	4.08	3.73	3.50	3.34	3.22	3.12	3.05	2.99	2.89	2.79	2.68	2.63	2.57	2.51	2.45	2.38	2.32
17	6.04	4.62	4.01	3.66	3.44	3.28	3.16	3.06	2.98	2.92	2.82	2.72	2.62	2.56	2.50	2.44	2.38	2.32	2.25
18	5.98	4.56	3.95	3.61	3.38	3.22	3.10	3.01	2.93	2.87	2.77	2.67	2.56	2.50	2.44	2.38	2.32	2.26	2.19
19	5.92	4.51	3.90	3.56	3.33	3.17	3.05	2.96	2.88	2.82	2.72	2.62	2.51	2.45	2.39	2.33	2.27	2.20	2.13
20	5.87	4.46	3.86	3.51	3.29	3.13	3.01	2.91	2.84	2.77	2.68	2.57	2.46	2.41	2.35	2.29	2.22	2.16	2.09
21	5.83	4.42	3.82	3.48	3.25	3.09	2.97	2.87	2.80	2.73	2.64	2.53	2.42	2.37	2.31	2.25	2.18	2.11	2.04
22	5.79	4.38	3.78	3.44	3.22	3.05	2.93	2.84	2.76	2.70	2.60	2.50	2.39	2.33	2.27	2.21	2.14	2.08	2.00
23	5.75	4.35	3.75	3.41	3.18	3.02	2.90	2.81	2.73	2.67	2.57	2.47	2.36	2.30	2.24	2.18	2.11	2.04	1.97
24	5.72	4.32	3.72	3.38	3.15	2.99	2.87	2.78	2.70	2.64	2.54	2.44	2.33	2.27	2.21	2.15	2.08	2.01	1.94
25	5.69	4.29	3.69	3.35	3.13	2.97	2.85	2.75	2.68	2.61	2.51	2.41	2.30	2.24	2.18	2.12	2.05	1.98	1.91
26	5.66	4.27	3.67	3.33	3.10	2.94	2.82	2.73	2.65	2.59	2.49	2.39	2.28	2.22	2.16	2.09	2.03	1.95	1.88
27	5.63	4.24	3.65	3.31	3.08	2.92	2.80	2.71	2.63	2.57	2.47	2.36	2.25	2.19	2.13	2.07	2.00	1.93	1.85
28	5.61	4.22	3.63	3.29	3.06	2.90	2.78	2.69	2.61	2.55	2.45	2.34	2.23	2.17	2.11	2.05	1.98	1.91	1.83
29	5.59	4.20	3.61	3.27	3.04	2.88	2.76	2.67	2.59	2.53	2.43	2.32	2.21	2.15	2.09	2.03	1.96	1.89	1.81
30	5.57	4.18	3.59	3.25	3.03	2.87	2.75	2.65	2.57	2.51	2.41	2.31	2.20	2.14	2.07	2.01	1.94	1.87	1.79
40	5.42	4.05	3.46	3.13	2.90	2.74	2.62	2.53	2.45	2.39	2.29	2.18	2.07	2.01	1.94	1.88	1.80	1.72	1.64
60	5.29	3.93	3.34	3.01	2.79	2.63	2.51	2.41	2.33	2.27	2.17	2.06	1.94	1.88	1.82	1.74	1.67	1.58	1.48
120	5.15	3.80	3.23	2.89	2.67	2.52	2.39	2.30	2.22	2.16	2.05	1.94	1.82	1.76	1.69	1.61	1.53	1.43	1.31
∞	5.02	3.69	3.12	2.79	2.57	2.41	2.29	2.19	2.11	2.05	1.94	1.83	1.71	1.64	1.57	1.48	1.39	1.27	1.00

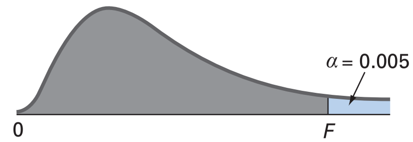
continued

TABLE E.5

Critical Values of *F* (*continued*)



Denominator, df_2	Cumulative Probabilities = 0.99 — Upper-Tail Areas = 0.01 — Numerator, df_1: 1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	4,052.00	4,999.50	5,403.00	5,625.00	5,764.00	5,859.00	5,928.00	5,982.00	6,022.00	6,056.00	6,106.00	6,157.00	6,209.00	6,235.00	6,261.00	6,287.00	6,313.00	6,339.00	6,366.00
2	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37	99.39	99.40	99.42	99.43	44.45	99.46	99.47	99.47	99.48	99.49	99.50
3	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.05	26.87	26.69	26.60	26.50	26.41	26.32	26.22	26.13
4	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.55	14.37	14.20	14.02	13.93	13.84	13.75	13.65	13.56	13.46
5	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16	10.05	9.89	9.72	9.55	9.47	9.38	9.29	9.20	9.11	9.02
6	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.72	7.56	7.40	7.31	7.23	7.14	7.06	6.97	6.88
7	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72	6.62	6.47	6.31	6.16	6.07	5.99	5.91	5.82	5.74	5.65
8	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91	5.81	5.67	5.52	5.36	5.28	5.20	5.12	5.03	4.95	4.86
9	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	5.26	5.11	4.96	4.81	4.73	4.65	4.57	4.48	4.40	4.31
10	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85	4.71	4.56	4.41	4.33	4.25	4.17	4.08	4.00	3.91
11	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	4.40	4.25	4.10	4.02	3.94	3.86	3.78	3.69	3.60
12	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	4.16	4.01	3.86	3.78	3.70	3.62	3.54	3.45	3.36
13	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	3.96	3.82	3.66	3.59	3.51	3.43	3.34	3.25	3.17
14	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	3.80	3.66	3.51	3.43	3.35	3.27	3.18	3.09	3.00
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.67	3.52	3.37	3.29	3.21	3.13	3.05	2.96	2.87
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.55	3.41	3.26	3.18	3.10	3.02	2.93	2.81	2.75
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68	3.59	3.46	3.31	3.16	3.08	3.00	2.92	2.83	2.75	2.65
18	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60	3.51	3.37	3.23	3.08	3.00	2.92	2.84	2.75	2.66	2.57
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52	3.43	3.30	3.15	3.00	2.92	2.84	2.76	2.67	2.58	2.49
20	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37	3.23	3.09	2.94	2.86	2.78	2.69	2.61	2.52	2.42
21	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40	3.31	3.17	3.03	2.88	2.80	2.72	2.64	2.55	2.46	2.36
22	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26	3.12	2.98	2.83	2.75	2.67	2.58	2.50	2.40	2.31
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21	3.07	2.93	2.78	2.70	2.62	2.54	2.45	2.35	2.26
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17	3.03	2.89	2.74	2.66	2.58	2.49	2.40	2.31	2.21
25	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22	3.13	2.99	2.85	2.70	2.62	2.54	2.45	2.36	2.27	2.17
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18	3.09	2.96	2.81	2.66	2.58	2.50	2.42	2.33	2.23	2.13
27	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15	3.06	2.93	2.78	2.63	2.55	2.47	2.38	2.29	2.20	2.10
28	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12	3.03	2.90	2.75	2.60	2.52	2.44	2.35	2.26	2.17	2.06
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09	3.00	2.87	2.73	2.57	2.49	2.41	2.33	2.23	2.14	2.03
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98	2.84	2.70	2.55	2.47	2.39	2.30	2.21	2.11	2.01
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80	2.66	2.52	2.37	2.29	2.20	2.11	2.02	1.92	1.80
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63	2.50	2.35	2.20	2.12	2.03	1.94	1.84	1.73	1.60
120	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56	2.47	2.34	2.19	2.03	1.95	1.86	1.76	1.66	1.53	1.38
∞	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32	2.18	2.04	1.88	1.79	1.70	1.59	1.47	1.32	1.00



Cumulative Probabilities = 0.995

Upper-Tail Areas = 0.005

Numerator, df_1

Denominator, df_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
1	16,211.00	20,000.00	21,615.00	22,500.00	23,056.00	23,437.00	23,715.00	23,925.00	24,091.00	24,224.00	24,426.00	24,630.00	24,836.00	24,910.00	25,044.00	25,148.00	25,253.00	25,359.00	25,465.00
2	198.50	199.00	199.20	199.20	199.30	199.30	199.40	199.40	199.40	199.40	199.40	199.40	199.40	199.50	199.50	199.50	199.50	199.50	199.50
3	55.55	49.80	47.47	46.19	45.39	44.84	44.43	44.13	43.88	43.69	43.39	43.08	42.78	42.62	42.47	42.31	42.15	41.99	41.83
4	31.33	26.28	24.26	23.15	22.46	21.97	21.62	21.35	21.14	20.97	20.70	20.44	20.17	20.03	19.89	19.75	19.61	19.47	19.32
5	22.78	18.31	16.53	15.56	14.94	14.51	14.20	13.96	13.77	13.62	13.38	13.15	12.90	12.78	12.66	12.53	12.40	12.27	12.11
6	18.63	14.54	12.92	12.03	11.46	11.07	10.79	10.57	10.39	10.25	10.03	9.81	9.59	9.47	9.36	9.24	9.12	9.00	8.88
7	16.24	12.40	10.88	10.05	9.52	9.16	8.89	8.68	8.51	8.38	8.18	7.97	7.75	7.65	7.53	7.42	7.31	7.19	7.08
8	14.69	11.04	9.60	8.81	8.30	7.95	7.69	7.50	7.34	7.21	7.01	6.81	6.61	6.50	6.40	6.29	6.18	6.06	5.95
9	13.61	10.11	8.72	7.96	7.47	7.13	6.88	6.69	6.54	6.42	6.23	6.03	5.83	5.73	5.62	5.52	5.41	5.30	5.19
10	12.83	9.43	8.08	7.34	6.87	6.54	6.30	6.12	5.97	5.85	5.66	5.47	5.27	5.17	5.07	4.97	4.86	4.75	4.61
11	12.23	8.91	7.60	6.88	6.42	6.10	5.86	5.68	5.54	5.42	5.24	5.05	4.86	4.75	4.65	4.55	4.44	4.34	4.23
12	11.75	8.51	7.23	6.52	6.07	5.76	5.52	5.35	5.20	5.09	4.91	4.72	4.53	4.43	4.33	4.23	4.12	4.01	3.90
13	11.37	8.19	6.93	6.23	5.79	5.48	5.25	5.08	4.94	4.82	4.64	4.46	4.27	4.17	4.07	3.97	3.87	3.76	3.65
14	11.06	7.92	6.68	6.00	5.56	5.26	5.03	4.86	4.72	4.60	4.43	4.25	4.06	3.96	3.86	3.76	3.66	3.55	3.41
15	10.80	7.70	6.48	5.80	5.37	5.07	4.85	4.67	4.54	4.42	4.25	4.07	3.88	3.79	3.69	3.58	3.48	3.37	3.26
16	10.58	7.51	6.30	5.64	5.21	4.91	4.69	4.52	4.38	4.27	4.10	3.92	3.73	3.64	3.54	3.44	3.33	3.22	3.11
17	10.38	7.35	6.16	5.50	5.07	4.78	4.56	4.39	4.25	4.14	3.97	3.79	3.61	3.51	3.41	3.31	3.21	3.10	2.98
18	10.22	7.21	6.03	5.37	4.96	4.66	4.44	4.28	4.14	4.03	3.86	3.68	3.50	3.40	3.30	3.20	3.10	2.99	2.87
19	10.07	7.09	5.92	5.27	4.85	4.56	4.34	4.18	4.04	3.93	3.76	3.59	3.40	3.31	3.21	3.11	3.00	2.89	2.78
20	9.94	6.99	5.82	5.17	4.76	4.47	4.26	4.09	3.96	3.85	3.68	3.50	3.32	3.22	3.12	3.02	2.92	2.81	2.69
21	9.83	6.89	5.73	5.09	4.68	4.39	4.18	4.02	3.88	3.77	3.60	3.43	3.24	3.15	3.05	2.95	2.84	2.73	2.61
22	9.73	6.81	5.65	5.02	4.61	4.32	4.11	3.94	3.81	3.70	3.54	3.36	3.18	3.08	2.98	2.88	2.77	2.66	2.55
23	9.63	6.73	5.58	4.95	4.54	4.26	4.05	3.88	3.75	3.64	3.47	3.30	3.12	3.02	2.92	2.82	2.71	2.60	2.48
24	9.55	6.66	5.52	4.89	4.49	4.20	3.99	3.83	3.69	3.59	3.42	3.25	3.06	2.97	2.87	2.77	2.66	2.55	2.43
25	9.48	6.60	5.46	4.84	4.43	4.15	3.94	3.78	3.64	3.54	3.37	3.20	3.01	2.92	2.82	2.72	2.61	2.50	2.38
26	9.41	6.54	5.41	4.79	4.38	4.10	3.89	3.73	3.60	3.49	3.33	3.15	2.97	2.87	2.77	2.67	2.56	2.45	2.33
27	9.34	6.49	5.36	4.74	4.34	4.06	3.85	3.69	3.56	3.45	3.28	3.11	2.93	2.83	2.73	2.63	2.52	2.41	2.29
28	9.28	6.44	5.32	4.70	4.30	4.02	3.81	3.65	3.52	3.41	3.25	3.07	2.89	2.79	2.69	2.59	2.48	2.37	2.25
29	9.23	6.40	5.28	4.66	4.26	3.98	3.77	3.61	3.48	3.38	3.21	3.04	2.86	2.76	2.66	2.56	2.45	2.33	2.21
30	9.18	6.35	5.24	4.62	4.23	3.95	3.74	3.58	3.45	3.34	3.18	3.01	2.82	2.73	2.63	2.52	2.42	2.30	2.18
40	8.83	6.07	4.98	4.37	3.99	3.71	3.51	3.35	3.22	3.12	2.95	2.78	2.60	2.50	2.40	2.30	2.18	2.06	1.93
60	8.49	5.79	4.73	4.14	3.76	3.49	3.29	3.13	3.01	2.90	2.74	2.57	2.39	2.29	2.19	2.08	1.96	1.83	1.69
120	8.18	5.54	4.50	3.92	3.55	3.28	3.09	2.93	2.81	2.71	2.54	2.37	2.19	2.09	1.98	1.87	1.75	1.61	1.43
∞	7.88	5.30	4.28	3.72	3.35	3.09	2.90	2.74	2.62	2.52	2.36	2.19	2.00	1.90	1.79	1.67	1.53	1.36	1.00

TABLE E.6

Critical Values of the Studentized Range, Q

Denominator, *df*	Upper 5% Points ($\alpha = 0.05$) Numerator, *df*																		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	17.97	26.98	32.82	37.08	40.41	43.12	45.40	47.36	49.07	50.59	51.96	53.20	54.33	55.36	56.32	57.22	58.04	58.83	59.56
2	6.09	8.33	9.80	10.88	11.74	12.44	13.03	13.54	13.99	14.39	14.75	15.08	15.38	15.65	15.91	16.14	16.37	16.57	16.77
3	4.50	5.91	6.83	7.50	8.04	8.48	8.85	9.18	9.46	9.72	9.95	10.15	10.35	10.53	10.61	10.84	10.98	11.11	11.24
4	3.93	5.04	5.76	6.29	6.71	7.05	7.35	7.60	7.83	8.03	8.21	8.37	8.53	8.66	8.79	8.91	9.03	9.13	9.23
5	3.64	4.60	5.22	5.67	6.03	6.33	6.58	6.80	7.00	7.17	7.32	7.47	7.60	7.72	7.83	7.93	8.03	8.12	8.21
6	3.46	4.34	4.90	5.31	5.63	5.90	6.12	6.32	6.49	6.65	6.79	6.92	7.03	7.14	7.24	7.34	7.43	7.51	7.59
7	3.34	4.17	4.68	5.06	5.36	5.61	5.82	6.00	6.16	6.30	6.43	6.55	6.66	6.76	6.85	6.94	7.02	7.10	7.17
8	3.26	4.04	4.53	4.89	5.17	5.40	5.60	5.77	5.92	6.05	6.18	6.29	6.39	6.48	6.57	6.65	6.73	6.80	6.87
9	3.20	3.95	4.42	4.76	5.02	5.24	5.43	5.60	5.74	5.87	5.98	6.09	6.19	6.28	6.36	6.44	6.51	6.58	6.64
10	3.15	3.88	4.33	4.65	4.91	5.12	5.31	5.46	5.60	5.72	5.83	5.93	6.03	6.11	6.20	6.27	6.34	6.41	6.47
11	3.11	3.82	4.26	4.57	4.82	5.03	5.20	5.35	5.49	5.61	5.71	5.81	5.90	5.98	6.06	6.13	6.20	6.27	6.33
12	3.08	3.77	4.20	4.51	4.75	4.95	5.12	5.27	5.40	5.51	5.62	5.71	5.80	5.88	5.95	6.02	6.09	6.15	6.21
13	3.06	3.74	4.15	4.45	4.69	4.89	5.05	5.19	5.32	5.43	5.53	5.63	5.71	5.79	5.86	5.93	6.00	6.06	6.11
14	3.03	3.70	4.11	4.41	4.64	4.83	4.99	5.13	5.25	5.36	5.46	5.55	5.64	5.71	5.79	5.85	5.92	5.97	6.03
15	3.01	3.67	4.08	4.37	4.60	4.78	4.94	5.08	5.20	5.31	5.40	5.49	5.57	5.65	5.72	5.79	5.85	5.90	5.96
16	3.00	3.65	4.05	4.33	4.56	4.74	4.90	5.03	5.15	5.26	5.35	5.44	5.52	5.59	5.66	5.73	5.79	5.84	5.90
17	2.98	3.63	4.02	4.30	4.52	4.71	4.86	4.99	5.11	5.21	5.31	5.39	5.47	5.54	5.61	5.68	5.73	5.79	5.84
18	2.97	3.61	4.00	4.28	4.50	4.67	4.82	4.96	5.07	5.17	5.27	5.35	5.43	5.50	5.57	5.63	5.69	5.74	5.79
19	2.96	3.59	3.98	4.25	4.47	4.65	4.79	4.92	5.04	5.14	5.23	5.32	5.39	5.46	5.53	5.59	5.65	5.70	5.75
20	2.95	3.58	3.96	4.23	4.45	4.62	4.77	4.90	5.01	5.11	5.20	5.28	5.36	5.43	5.49	5.55	5.61	5.66	5.71
24	2.92	3.53	3.90	4.17	4.37	4.54	4.68	4.81	4.92	5.01	5.10	5.18	5.25	5.32	5.38	5.44	5.49	5.55	5.59
30	2.89	3.49	3.85	4.10	4.30	4.46	4.60	4.72	4.82	4.92	5.00	5.08	5.15	5.21	5.27	5.33	5.38	5.43	5.48
40	2.86	3.44	3.79	4.04	4.23	4.39	4.52	4.64	4.74	4.82	4.90	4.98	5.04	5.11	5.16	5.22	5.27	5.31	5.36
60	2.83	3.40	3.74	3.98	4.16	4.31	4.44	4.55	4.65	4.73	4.81	4.88	4.94	5.00	5.06	5.11	5.15	5.20	5.24
120	2.80	3.36	3.69	3.92	4.10	4.24	4.36	4.47	4.56	4.64	4.71	4.78	4.84	4.90	4.95	5.00	5.04	5.09	5.13
∞	2.77	3.31	3.63	3.86	4.03	4.17	4.29	4.39	4.47	4.55	4.62	4.68	4.74	4.80	4.85	4.89	4.93	4.97	5.01

continued

TABLE E.6

Critical Values of the Studentized Range, Q

Denominator, *df*	Upper 1% Points ($\alpha = 0.01$) Numerator, *df* 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	90.03	135.00	164.30	185.60	202.20	215.80	227.20	237.00	245.60	253.20	260.00	266.20	271.80	277.00	281.80	286.30	290.40	294.30	298.00
2	14.04	19.02	22.29	24.72	26.63	28.20	29.53	30.68	31.69	32.59	33.40	34.13	34.81	35.43	36.00	36.53	37.03	37.50	37.95
3	8.26	10.62	12.17	13.33	14.24	15.00	15.64	16.20	16.69	17.13	17.53	17.89	18.22	18.52	18.81	19.07	19.32	19.55	19.77
4	6.51	8.12	9.17	9.96	10.58	11.10	11.55	11.93	12.27	12.57	12.84	13.09	13.32	13.53	13.73	13.91	14.08	14.24	14.40
5	5.70	6.98	7.80	8.42	8.91	9.32	9.67	9.97	10.24	10.48	10.70	10.89	11.08	11.24	11.40	11.55	11.68	11.81	11.93
6	5.24	6.33	7.03	7.56	7.97	8.32	8.61	8.87	9.10	9.30	9.49	9.65	9.81	9.95	10.08	10.21	10.32	10.43	10.54
7	4.95	5.92	6.54	7.01	7.37	7.68	7.94	8.17	8.37	8.55	8.71	8.86	9.00	9.12	9.24	9.35	9.46	9.55	9.65
8	4.75	5.64	6.20	6.63	6.96	7.24	7.47	7.68	7.86	8.03	8.18	8.31	8.44	8.55	8.66	8.76	8.85	8.94	9.03
9	4.60	5.43	5.96	6.35	6.66	6.92	7.13	7.32	7.50	7.65	7.78	7.91	8.03	8.13	8.23	8.33	8.41	8.50	8.57
10	4.48	5.27	5.77	6.14	6.43	6.67	6.87	7.06	7.21	7.36	7.49	7.60	7.71	7.81	7.91	7.99	8.08	8.15	8.23
11	4.39	5.15	5.62	5.97	6.25	6.48	6.67	6.84	6.99	7.13	7.25	7.36	7.47	7.56	7.65	7.73	7.81	7.88	7.95
12	4.32	5.04	5.50	5.84	6.10	6.32	6.51	6.67	6.81	6.94	7.06	7.17	7.26	7.36	7.44	7.52	7.59	7.66	7.73
13	4.26	4.96	5.40	5.73	5.98	6.19	6.37	6.53	6.67	6.79	6.90	7.01	7.10	7.19	7.27	7.35	7.42	7.49	7.55
14	4.21	4.90	5.32	5.63	5.88	6.09	6.26	6.41	6.54	6.66	6.77	6.87	6.96	7.05	7.13	7.20	7.27	7.33	7.40
15	4.17	4.84	5.25	5.56	5.80	5.99	6.16	6.31	6.44	6.56	6.66	6.76	6.85	6.93	7.00	7.07	7.14	7.20	7.26
16	4.13	4.79	5.19	5.49	5.72	5.92	6.08	6.22	6.35	6.46	6.56	6.66	6.74	6.82	6.90	6.97	7.03	7.09	7.15
17	4.10	4.74	5.14	5.43	5.66	5.85	6.01	6.15	6.27	6.38	6.48	6.57	6.66	6.73	6.81	6.87	6.94	7.00	7.05
18	4.07	4.70	5.09	5.38	5.60	5.79	5.94	6.08	6.20	6.31	6.41	6.50	6.58	6.66	6.73	6.79	6.85	6.91	6.97
19	4.05	4.67	5.05	5.33	5.55	5.74	5.89	6.02	6.14	6.25	6.34	6.43	6.51	6.59	6.65	6.72	6.78	6.84	6.89
20	4.02	4.64	5.02	5.29	5.51	5.69	5.84	5.97	6.09	6.19	6.29	6.37	6.45	6.52	6.59	6.65	6.71	6.77	6.82
24	3.96	4.55	4.91	5.17	5.37	5.54	5.69	5.81	5.92	6.02	6.11	6.19	6.26	6.33	6.39	6.45	6.51	6.56	6.61
30	3.89	4.46	4.80	5.05	5.24	5.40	5.54	5.65	5.76	5.85	5.93	6.01	6.08	6.14	6.20	6.26	6.31	6.36	6.41
40	3.83	4.37	4.70	4.93	5.11	5.27	5.39	5.50	5.60	5.69	5.76	5.84	5.90	5.96	6.02	6.07	6.12	6.17	6.21
60	3.76	4.28	4.60	4.82	4.99	5.13	5.25	5.36	5.45	5.53	5.60	5.67	5.73	5.79	5.84	5.89	5.93	5.97	6.02
120	3.70	4.20	4.50	4.71	4.87	5.01	5.12	5.21	5.30	5.38	5.44	5.51	5.56	5.61	5.66	5.71	5.75	5.79	5.83
∞	3.64	4.12	4.40	4.60	4.76	4.88	4.99	5.08	5.16	5.23	5.29	5.35	5.40	5.45	5.49	5.54	5.57	5.61	5.65

Source: Extracted from H. L. Harter and D. S. Clemm, "The Probability Integrals of the Range and of the Studentized Range—Probability Integral, Percentage Points, and Moments of the Range," *Wright Air Development Technical Report 58–484,* Vol. 1, 1959.

TABLE E.7

Critical Values, d_L and d_U, of the Durbin-Watson Statistic, D (Critical Values Are One-Sided)[a]

	$\alpha = 0.05$										$\alpha = 0.01$									
	$k = 1$		$k = 2$		$k = 3$		$k = 4$		$k = 5$		$k = 1$		$k = 2$		$k = 3$		$k = 4$		$k = 5$	
n	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
15	1.08	1.36	.95	1.54	.82	1.75	.69	1.97	.56	2.21	.81	1.07	.70	1.25	.59	1.46	.49	1.70	.39	1.96
16	1.10	1.37	.98	1.54	.86	1.73	.74	1.93	.62	2.15	.84	1.09	.74	1.25	.63	1.44	.53	1.66	.44	1.90
17	1.13	1.38	1.02	1.54	.90	1.71	.78	1.90	.67	2.10	.87	1.10	.77	1.25	.67	1.43	.57	1.63	.48	1.85
18	1.16	1.39	1.05	1.53	.93	1.69	.82	1.87	.71	2.06	.90	1.12	.80	1.26	.71	1.42	.61	1.60	.52	1.80
19	1.18	1.40	1.08	1.53	.97	1.68	.86	1.85	.75	2.02	.93	1.13	.83	1.26	.74	1.41	.65	1.58	.56	1.77
20	1.20	1.41	1.10	1.54	1.00	1.68	.90	1.83	.79	1.99	.95	1.15	.86	1.27	.77	1.41	.68	1.57	.60	1.74
21	1.22	1.42	1.13	1.54	1.03	1.67	.93	1.81	.83	1.96	.97	1.16	.89	1.27	.80	1.41	.72	1.55	.63	1.71
22	1.24	1.43	1.15	1.54	1.05	1.66	.96	1.80	.86	1.94	1.00	1.17	.91	1.28	.83	1.40	.75	1.54	.66	1.69
23	1.26	1.44	1.17	1.54	1.08	1.66	.99	1.79	.90	1.92	1.02	1.19	.94	1.29	.86	1.40	.77	1.53	.70	1.67
24	1.27	1.45	1.19	1.55	1.10	1.66	1.01	1.78	.93	1.90	1.04	1.20	.96	1.30	.88	1.41	.80	1.53	.72	1.66
25	1.29	1.45	1.21	1.55	1.12	1.66	1.04	1.77	.95	1.89	1.05	1.21	.98	1.30	.90	1.41	.83	1.52	.75	1.65
26	1.30	1.46	1.22	1.55	1.14	1.65	1.06	1.76	.98	1.88	1.07	1.22	1.00	1.31	.93	1.41	.85	1.52	.78	1.64
27	1.32	1.47	1.24	1.56	1.16	1.65	1.08	1.76	1.01	1.86	1.09	1.23	1.02	1.32	.95	1.41	.88	1.51	.81	1.63
28	.33	1.48	1.26	1.56	1.18	1.65	1.10	1.75	1.03	1.85	1.10	1.24	1.04	1.32	.97	1.41	.90	1.51	.83	1.62
29	1.34	1.48	1.27	1.56	1.20	1.65	1.12	1.74	1.05	1.84	1.12	1.25	1.05	1.33	.99	1.42	.92	1.51	.85	1.61
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83	1.13	1.26	1.07	1.34	1.01	1.42	.94	1.51	.88	1.61
31	1.36	1.50	1.30	1.57	1.23	1.65	1.16	1.74	1.09	1.83	1.15	1.27	1.08	1.34	1.02	1.42	.96	1.51	.90	1.60
32	1.37	1.50	1.31	1.57	1.24	1.65	1.18	1.73	1.11	1.82	1.16	1.28	1.10	1.35	1.04	1.43	.98	1.51	.92	1.60
33	1.38	1.51	1.32	1.58	1.26	1.65	1.19	1.73	1.13	1.81	1.17	1.29	1.11	1.36	1.05	1.43	1.00	1.51	.94	1.59
34	1.39	1.51	1.33	1.58	1.27	1.65	1.21	1.73	1.15	1.81	1.18	1.30	1.13	1.36	1.07	1.43	1.01	1.51	.95	1.59
35	1.40	1.52	1.34	1.58	1.28	1.65	1.22	1.73	1.16	1.80	1.19	1.31	1.14	1.37	1.08	1.44	1.03	1.51	.97	1.59
36	1.41	1.52	1.35	1.59	1.29	1.65	1.24	1.73	1.18	1.80	1.21	1.32	1.15	1.38	1.10	1.44	1.04	1.51	.99	1.59
37	1.42	1.53	1.36	1.59	1.31	1.66	1.25	1.72	1.19	1.80	1.22	1.32	1.16	1.38	1.11	1.45	1.06	1.51	1.00	1.59
38	1.43	1.54	1.37	1.59	1.32	1.66	1.26	1.72	1.21	1.79	1.23	1.33	1.18	1.39	1.12	1.45	1.07	1.52	1.02	1.58
39	1.43	1.54	1.38	1.60	1.33	1.66	1.27	1.72	1.22	1.79	1.24	1.34	1.19	1.39	1.14	1.45	1.09	1.52	1.03	1.58
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79	1.25	1.34	1.20	1.40	1.15	1.46	1.10	1.52	1.05	1.58
45	1.48	1.57	1.43	1.62	1.38	1.67	1.34	1.72	1.29	1.78	1.29	1.38	1.24	1.42	1.20	1.48	1.16	1.53	1.11	1.58
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77	1.32	1.40	1.28	1.45	1.24	1.49	1.20	1.54	1.16	1.59
55	1.53	1.60	1.49	1.64	1.45	1.68	1.41	1.72	1.38	1.77	1.36	1.43	1.32	1.47	1.28	1.51	1.25	1.55	1.21	1.59
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77	1.38	1.45	1.35	1.48	1.32	1.52	1.28	1.56	1.25	1.60
65	1.57	1.63	1.54	1.66	1.50	1.70	1.47	1.73	1.44	1.77	1.41	1.47	1.38	1.50	1.35	1.53	1.31	1.57	1.28	1.61
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77	1.43	1.49	1.40	1.52	1.37	1.55	1.34	1.58	1.31	1.61
75	1.60	1.65	1.57	1.68	1.54	1.71	1.51	1.74	1.49	1.77	1.45	1.50	1.42	1.53	1.39	1.56	1.37	1.59	1.34	1.62
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77	1.47	1.52	1.44	1.54	1.42	1.57	1.39	1.60	1.36	1.62
85	1.62	1.67	1.60	1.70	1.57	1.72	1.55	1.75	1.52	1.77	1.48	1.53	1.46	1.55	1.43	1.58	1.41	1.60	1.39	1.63
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78	1.50	1.54	1.47	1.56	1.45	1.59	1.43	1.61	1.41	1.64
95	1.64	1.69	1.62	1.71	1.60	1.73	1.58	1.75	1.56	1.78	1.51	1.55	1.49	1.57	1.47	1.60	1.45	1.62	1.42	1.64
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78	1.52	1.56	1.50	1.58	1.48	1.60	1.46	1.63	1.44	1.65

[a] n = number of observations; k = number of independent variables.

Source: Computed from TSP 4.5 based on R. W. Farebrother, "A Remark on Algorithms AS106, AS153, and AS155: The Distribution of a Linear Combination of Chi-Square Random Variables," *Journal of the Royal Statistical Society,* Series C (Applied Statistics), 1984, 29, p. 323–333.

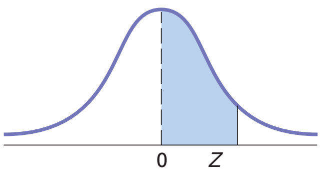
TABLE E.8
Control Chart Factors

Number of Observations in Sample/Subgroup (*n*)	d_2	d_3	D_3	D_4	A_2
2	1.128	0.853	0	3.267	1.880
3	1.693	0.888	0	2.575	1.023
4	2.059	0.880	0	2.282	0.729
5	2.326	0.864	0	2.114	0.577
6	2.534	0.848	0	2.004	0.483
7	2.704	0.833	0.076	1.924	0.419
8	2.847	0.820	0.136	1.864	0.373
9	2.970	0.808	0.184	1.816	0.337
10	3.078	0.797	0.223	1.777	0.308
11	3.173	0.787	0.256	1.744	0.285
12	3.258	0.778	0.283	1.717	0.266
13	3.336	0.770	0.307	1.693	0.249
14	3.407	0.763	0.328	1.672	0.235
15	3.472	0.756	0.347	1.653	0.223
16	3.532	0.750	0.363	1.637	0.212
17	3.588	0.744	0.378	1.622	0.203
18	3.640	0.739	0.391	1.609	0.194
19	3.689	0.733	0.404	1.596	0.187
20	3.735	0.729	0.415	1.585	0.180
21	3.778	0.724	0.425	1.575	0.173
22	3.819	0.720	0.435	1.565	0.167
23	3.858	0.716	0.443	1.557	0.162
24	3.895	0.712	0.452	1.548	0.157
25	3.931	0.708	0.459	1.541	0.153

Source: Reprinted from *ASTM-STP 15D* by kind permission of the American Society for Testing and Materials.

TABLE E.9
The Standardized Normal Distribution

Entry represents area under the standardized normal distribution from the mean to *Z*



Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.49865	.49869	.49874	.49878	.49882	.49886	.49889	.49893	.49897	.49900
3.1	.49903	.49906	.49910	.49913	.49916	.49918	.49921	.49924	.49926	.49929
3.2	.49931	.49934	.49936	.49938	.49940	.49942	.49944	.49946	.49948	.49950
3.3	.49952	.49953	.49955	.49957	.49958	.49960	.49961	.49962	.49964	.49965
3.4	.49966	.49968	.49969	.49970	.49971	.49972	.49973	.49974	.49975	.49976
3.5	.49977	.49978	.49978	.49979	.49980	.49981	.49981	.49982	.49983	.49983
3.6	.49984	.49985	.49985	.49986	.49986	.49987	.49987	.49988	.49988	.49989
3.7	.49989	.49990	.49990	.49990	.49991	.49991	.49992	.49992	.49992	.49992
3.8	.49993	.49993	.49993	.49994	.49994	.49994	.49994	.49995	.49995	.49995
3.9	.49995	.49995	.49996	.49996	.49996	.49996	.49996	.49996	.49997	.49997

APPENDIX F Additional Excel Procedures

F.1 Enhancing Workbook Presentation

You can enhance workbook presentation by using common formatting commands and rearranging the order of the worksheets and chart sheets in a workbook.

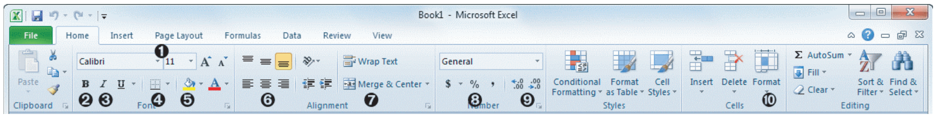
Table F.1 presents the shortcuts for worksheet formatting operations used to create the Excel Guide workbooks and the results shown throughout this book. These shortcuts can be found in the Home tab of the Excel Office Ribbon (see Figure F.1).

TABLE F.1
Shortcuts to Common Formatting Operations

Number	Operation Name	Use
❶	Font Face and Font Size	Changes the text font face and size for cell entries and chart labels. Worksheets shown in this book have been formatted as **Calibri 11**. Many DATA worksheets have been formatted as **Arial 10**.
❷	Boldface	Toggles on (or off) boldface text style for the currently selected object.
❸	Italic	Toggles on (or off) italic text style for the currently selected object.
❹	Borders	Displays a gallery of choices that permit drawing lines (borders) around a cell or cell range.
❺	Fill Color	Displays a gallery of choices for the background color of a cell. Immediately to the right of **Fill Color** is the related **Font Color** (not used in any example in this book).
❻	Align Text	Aligns the display of the contents of a worksheet cell. Three buttons are available: **Align Text Left**, **Center**, and **Align Text Right**.
❼	Merge & Center	Merges (combines) adjacent cells into one cell and centers the display of the contents of that cell. In Excel 2007, this button is also a drop-down list that offers additional **Merge** and **Unmerge** choices.
❽	Percent	Formats the display of a number value in a cell as a percentage. The value 1 displays as 100%, the value 0.01 displays as 1%. To the immediate left of **Percent** is **Currency**, which formats values as dollars and cents. Do not confuse **Currency** formatting with the symbol used to identify absolute cell references (discussed in Section EG1.7).
❾	Increase Decimal and Decrease Decimal	Adjusts the number of decimal places to display a number value in a cell.
❿	Format	Displays a gallery of choices that affect the row height and column width of a cell. The most common usage is to select a column and then select **Format ➔ AutoFit Column Width**.

FIGURE F.1

Home tab of the Excel Office Ribbon (with number labels keyed to Table F.1)



Use the **Move or Copy** command to rearrange the order of the worksheets and chart sheets in a workbook. To move or copy a worksheet, right-click the worksheet sheet tab and click **Move or Copy** in the shortcut menu that appears. In the Move or Copy dialog box, select the destination workbook from the **To book** drop-down list—select **(new book)** to place the worksheet in a new workbook—and select a position for the worksheet in the **Before sheet** list. If making a copy, also check **Create a copy**. Click **OK** to complete the move or copy operation.

Worksheet cell formatting can also be done through the **Format Cells** command. When editing a worksheet, right-click a cell and then click **Format Cells** from the shortcut menu. In the Format Cells dialog box that appears, you can perform all the formatting operations discussed in Table F.1 and more.

F.2 Useful Keyboard Shortcuts

In Excel, certain keys or keystroke combinations (one or more keys held down as you press another key) are keyboard shortcuts that act as alternate means of executing common operations. Table F.2 presents some common shortcuts that represent some of the common Excel operations described in this book. (Keystroke combinations are shown using a plus sign, as in **Ctrl+C**, which means "while holding down the **Ctrl** key, press the **C** key.")

TABLE F.2

Useful Keyboard Shortcuts

Key	Operation
Backspace	Erases typed characters to the left of the current position, one character at a time.
Delete	Erases characters to the right of the cursor, one character at a time.
Enter or Tab	Finalizes an entry typed into a worksheet cell. Implied by the use of the verb *enter* in the Excel Guides.
Esc	Cancels an action or a dialog box. Equivalent to the dialog box **Cancel** button.
F1	Displays the Excel help system.
Ctrl+C	Copies the currently selected worksheet entry or chart label.
Ctrl+V	Pastes the currently copied object into the currently selected worksheet cell or chart label.
Ctrl+X	Cuts the currently selected worksheet entry or chart label. You cut, and not delete, something in order to paste it somewhere else.
Ctrl+B	Toggles on (or off) boldface text style for the currently selected object.
Ctrl+I	Toggles on (or off) italic text style for the currently selected object.
Ctrl+F	Finds a **Find what** value.
Ctrl+H	Replaces a **Find what** value with the **Replace with** value.
Ctrl+Z	Undoes the last operation.
Ctrl+Y	Redoes the last operation.
Ctrl+`	Toggles on (or off) formulas view of worksheet.
Ctrl+Shift+Enter	Enters an array formula.

Note: Using the copy-and-paste keyboard shortcut, Ctrl+C and Ctrl+V, to copy formulas from one worksheet cell to another is subject to the same type of adjustment as discussed in Section EG1.7.

F.3 Verifying Formulas and Worksheets

If you use formulas in your worksheets, you should review and verify formulas before you use their results. To view the formulas in a worksheet, press Ctrl+` (grave accent key). To restore the original view, the results of the formulas, press Ctrl+` a second time.

As you create and use more complicated worksheets, you might want to visually examine the relationships among a formula and the cells it uses (called the *precedents*) and the cells that use the results of the formula (the *dependents*). Select **Formulas ➔ Trace Precedents** (or **Trace Dependents**). When you are finished, clear all trace arrows by selecting **Formulas ➔ Remove Arrows**.

F.4 Chart Formatting

Excel incorrectly formats the charts created by the *In-Depth Excel* instructions. Use the formatting adjustments in Table F.3 to properly format charts you create. Before applying these adjustments, relocate a chart to its own chart sheet. To do so, right-click the chart background and click **Move Chart** from the shortcut menu. In the Move Chart dialog box, click **New Sheet**, enter a name for the new chart sheet, and click **OK**.

TABLE F.3
Excel Chart Formatting Adjustments

Layout Tab Selection	Notes
Chart Title ➔ Above Chart	In the box that is added to the chart, double-click **Chart Title** and enter an appropriate title.
Axes Titles ➔ Primary Horizontal Axis Title ➔ Title Below Axis	In the box that is added to the chart, double-click **Axis Title** and enter an appropriate title.
Axes Titles ➔ Primary Vertical Axis Title ➔ Rotated Title	In the box that is added to the chart, double-click **Axis Title** and enter an appropriate title.
Axes Titles ➔ Secondary Horizontal ➔ Axis Title ➔ None and **Axes Titles ➔ Secondary Vertical Axis Title ➔ Rotated Title**	Only for charts that contain secondary axes.
Legend ➔ None	Turns off the chart legend.
Data Labels ➔ None	Turns off the display of values at plotted points or bars in the charts.
Data Table ➔ None	Turns off the display of a summary table on the chart sheet.
Axes ➔ Primary Horizontal Axis ➔ Show Left to Right Axis (or **Show Default Axis**, if listed)	Turns on the display of the X axis.
Axes ➔ Primary Vertical Axis ➔ Show Default Axis	Turns on the display of the Y axis.
Gridlines ➔ Primary Horizontal Gridlines ➔ None	Turns off the improper horizontal gridlines.
Gridlines ➔ Primary Vertical Gridlines ➔ None	Turns off the improper vertical gridlines.

Use all of the adjustments in Table F.3, unless a particular set of charting instructions tells you otherwise. To apply the adjustments, you must be open to the chart sheet that contains the chart to be adjusted. All adjustments are made by first selecting the **Layout** tab (under the Chart Tools heading). If a Layout tab selection cannot be made, the adjustment does not apply to the type of chart being adjusted. (Excel hides or disables chart formatting choices that do not apply to a particular chart type.)

Occasionally, when you open to a chart sheet, the chart is either too large to be fully seen or too small, surrounded by a chart frame mat that is too large. Click the **Zoom Out** or **Zoom In** buttons, located in the lower-right portion of the Excel window frame, to adjust the display.

F.5 Creating Histograms for Discrete Probability Distributions

You can create a histogram for a discrete probability distribution based on a discrete probabilities table. For example, to create a histogram based on the Figure 5.2 binomial probabilities worksheet, open to the **COMPUTE worksheet** of the **Binomial workbook**. Select the cell range **B14:B18**, the probabilities in the Binomial Probabilities Table, and:

1. Select **Insert ➔ Column** and select the first **2-D Column** gallery choice **(Clustered Column)**.
2. Right-click the chart background and click **Select Data**.

In the Select Data Source dialog box:

3. Click **Edit** under the **Horizontal (Categories) Axis Labels** heading.
4. In the Axis Labels dialog box, enter **=COMPUTE!A14:A18** the cell range of the *X* axis values. (This cell range must be entered as a formula in the form **=*SheetName!CellRange***.) Then, click **OK** to return to the Select Data Source dialog box.
5. Click **OK**.

In the chart:

6. Right-click inside a bar and click **Format Data Series** in the shortcut menu.

In the Format Data Series dialog box:

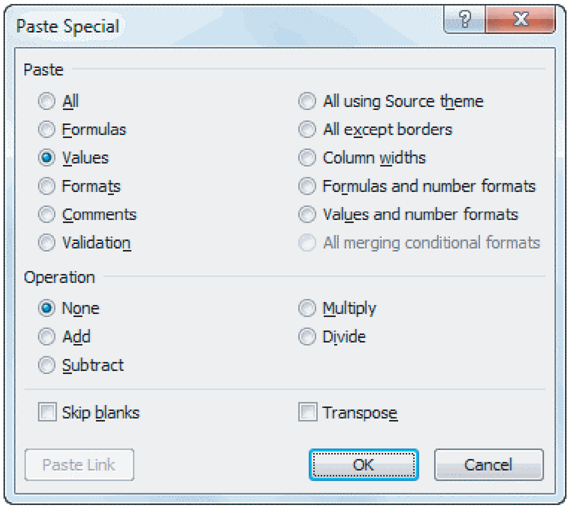
7. Click **Series Options** in the left pane. In the Series Options right pane, change the **Gap Width** slider to **Large Gap**. Click **Close**.

Relocate the chart to a chart sheet and adjust the chart formatting by using the instructions in Section F.4.

F.6 Pasting with Paste Special

Pasting data from one worksheet to another can sometimes cause unexpected side effects. When the two worksheets are in different workbooks, a simple paste creates an external link to the original workbook. This can lead to errors later if the first workbook is unavailable when the second one is being used. Even pasting between worksheets in the same workbook can lead to problems if what is being pasted is a cell range of formulas.

To avoid such side effects, use **Paste Special** in these special situations. To use this operation, copy the original cell range as you would do normally and select the cell or cell range to be the target of the paste. Right-click the target and click **Paste Special** from the shortcut menu. In the Paste Special dialog box (shown on the next page), click **Values** and then click **OK**. For the first case, Paste Special Values pastes the current values of the cells in the first workbook and not formulas that use cell references to the first workbook. For the second case, Paste Special Values pastes the current evaluation of the formulas copied and not the formulas themselves.



If you use PHStat2 and have data for a procedure in the form of formulas, use Paste Special Values to create columns of equivalent values before using the procedure. (PHStat2 will not work properly if data for a procedure are in the form of formulas.) Paste Special can paste other types of information, including cell formatting information. For a full discussion of Paste Special, see the Excel help system.

APPENDIX G PHStat2, Excel, and Minitab FAQs

G.1 PHStat2 FAQs

What is PHStat2?
PHStat2 is software that makes operating Windows-based Microsoft Excel as distraction free as possible. As a student studying statistics, you can focus mainly on learning statistics and not worry about having to fully master Excel first. PHStat2 contains just about all the statistical methods taught in an introductory statistics course that can be illustrated using Excel.

Which versions of Excel are compatible with PHStat2?
PHStat2 works with Excel 2003 and 32-bit versions of Excel 2007 and Excel 2010. PHStat2 does not work with any Excel version for the Mac. (Mac users can use virtualizing software to run Microsoft Windows and Excel 2003, 2007, or 2010 on their systems in order to use PHStat2.)

How do I get started using PHStat2?
Read the instructions in Section D.2 and complete the checklist. As that section states, be sure to completely review the PHStat2 readme file before attempting to add PHStat2 to your system.

Where can I find help if I have problems setting up PHStat2?
If you need help when you set up PHStat2, first review the "Troubleshooting PHStat2" section of the downloadable PHStat2 readme file. If you require additional assistance, visit the PHStat2 website (**www.pearsonhighered.com/phstat**) and go to the web page for your version (see next question) to see if there is any additional information to help you. If necessary, click the **Contact Pearson Technical Support** to contact Pearson Education Customer Technical Support. (Technical Support staff cannot answer questions about the statistical applications of PHStat2 or questions about specific PHStat2 procedures.)

How can I identify which PHStat2 version I have?
Open Microsoft Excel with PHStat2 and select **PHStat ➔ Help for PHStat**. In the dialog box that appears, note the XLA and DLL version numbers. If you downloaded and installed the PHStat2 version designed for this book, both of these numbers will not be lower than 3.3.

How can I be sure that my version of PHStat2 is up-to-date?
The PHStat2 setup program that you can download as part of the online resources for this book (see Appendix C) will always be the most up-to-date version for use with this book. Slight revisions of PHStat2 may occur during the lifetime of this edition. Those revisions will be noted on the PHStat2 website **(www.pearsonhighered.com/phstat)** and reflected in the copy of the PHStat2 setup program you can download.

Where can I find tips for using PHStat2?
While your classmates and instructor can be the best sources of tips, you can check the website www.pearsonhighered.com/phstat for FAQs or the Help file downloadable with PHStat.

G.2 Excel FAQs

What does "Compatibility Mode" in the title bar mean?
Excel displays "Compatibility Mode" when the workbook you are currently using has been previously stored using the **.xls** file format that is compatible with all Excel versions. Compatibility Mode does not affect Excel functionality but will cause Excel to review your workbook for exclusive-to-Excel-2007-or-2010 formatting properties and objects the next time you save the workbook. (To preserve exclusive features in Excel 2010, select **File ➔ Save As** and select **Excel Workbook (*.xlsx)** from the **Save as type** drop-down list. To preserve exclusive features in Excel 2007, click the **Office Button**, move the mouse pointer over **Save As**, and in the Save As gallery, click **Excel Workbook** to save the workbook in the **.xlsx** file format.)

If you open any of the Excel data or Excel Guide work-books for this book, you will see "Compatibility Mode," as all workbooks for this book have been stored using the **.xls** format. Generally, it makes little difference whether you use compatibility mode or not. The one exception is when working with PivotTables, as explained in Section EG2.7.)

In Excel 2010, how can I specify the custom settings that you recommend?
Select **File ➔ Options**. In the Excel Options dialog box, click **Formulas** in the left pane, and in the **Formulas** right pane, click **Automatic** under Workbook Calculation and verify that all check boxes are checked except **Enable iterative calculation**, **R1C1 reference style**, and **Formulas referring to empty cells**.

In Excel 2007, how can I specify the custom settings that you recommend?
Click the **Office Button** and then click **Excel Options**. In the Excel Options dialog box, click **Formulas** in the left pane, and in the **Formulas** right pane, click **Automatic** under Workbook Calculation and verify that all check boxes

are checked except **Enable iterative calculation**, **R1C1 reference style**, and **Formulas referring to empty cells**.

What Excel security settings will allow the PHStat2 or Visual Explorations add-in to function properly?
Use the instructions in Appendix Section D.3 for configuring Excel for PHStat2 for both add-ins.

I do not see the menu for the Visual Explorations (or PHStat2) add-in that I opened. Where is it?
Unlike earlier versions of Excel that allowed add-ins to add menus to the menu bar, Excel 2007 and 2010 places all add-in menus under the Add-ins tab. In order to see the menu, click **Add-ins** and then click the name of the add-in menu.

How can I install the Analysis ToolPak?
Close Excel and rerun the Microsoft Office or Microsoft Excel setup program. When the setup program runs, choose the option that allows you to add components which will be labeled either as **Change** or **Add or Remove Features**. (If you use Windows 7, open the **Programs and Features** Control Panel applet, select the entry for your version or Office or Excel, and then click **Change** at the top of the list of programs.)

In the Installation Options screen, double-click **Microsoft Office Excel** and then double-click **Add-ins.** Click the **Analysis ToolPak** drop-down list button and select **Run from My Computer**. (You may need access to the original Microsoft Office setup program to complete this task.) Upon successful installation, you will see **Data Analysis** as a choice in the **Analysis** group of the **Data** tab when you next open Excel.

G.3 FAQs for Minitab

Can I use Minitab Release 14 or 15 with this book?
Yes, you can use the Minitab Guide instructions, written for Minitab 16, with Release 14 or 15. For certain methods, there may be minor differences in labeling of dialog box elements. Any difference that is not minor is noted in the instructions.

Can I save my Minitab worksheets or projects for use with Release 14 or 15?
Yes. Select either **Minitab14** or **Minitab 15** (for a worksheet) or **Minitab 14 Project (*.MPJ)** or **Minitab 15 Project (*.MPJ)** (for a project) from the **Save as type** drop-down list in the save as dialog box. See Section MG1.3 for more information about using the Save Worksheet As and Save Project As dialog boxes.

Self-Test Solutions and Answers to Selected Even-Numbered Problems

The following represent worked-out solutions to Self-Test Problems and brief answers to most of the even-numbered problems in the text. For more detailed solutions, including explanations, interpretations, and Excel and Minitab results, see the *Student Solutions Manual*.

CHAPTER 1

1.2 Grande, medium, and small sizes represent different categories.

1.4 (a) The number of books is a numerical variable that is discrete because the outcome is a count. **(b)** The number of liters of milk is a numerical variable that is continuous because any value within a range of values can occur. **(c)** Whether a phone can make international calls is a categorical variable because the answer can only be yes or no. **(d)** Same answer as in (b). (**e**) Same answer as in (a). (**f**) Same answer as in (b).

1.6 (a) Categorical **(b)** Numerical, continuous **(c)** Numerical, discrete **(d)** Numerical, discrete (**e**) Categorical.

1.8 (a) Numerical, continuous **(b)** Numerical, discrete **(c)** Numerical, continuous **(d)** Categorical.

1.10 The underlying variable, ability of the students, may be continuous, but the measuring device, the test, does not have enough precision to distinguish between the two students.

1.20 (a) All 3,727 full-time first-year students at the university. (**b**) The 2,821 students who responded to the survey. **(c)** The proportion of all 3,727 students who studied with other students. **(d)** The proportion of the sample of 2,821 responding students who studied with other students.

1.22 (**a**) Adults living in the United States, aged 18 and older.**(b)** The 1,000 or more adults living in the United States, aged 18 and older, who were selected in the sample. **(c)** Because the 74% is based on the sample, it is a statistic. (d) Because the 40% is based on the sample, it is a statistic.

1.26 (a) Continous, categorical, categorical, continuous.

1.28 Gender, graduate major, undergraduate major, employment status, satisfaction with MBA advisory services, and preferred type of computer are categorical variables. Age, graduate grade point average, undergraduate grade point average, number of full-time jobs, expected starting salary, spending for textbooks and supplies, advisory rating, number of text messages sent in a typical week, and the amount of wealth needed to feel rich are numerical variables.

CHAPTER 2

2.6 (a) Table of frequencies for all student responses.

GENDER	STUDENT MAJOR CATEGORIES A	C	M	Totals
Male	14	9	2	25
Female	6	6	3	15
Totals	20	15	5	40

(b) Table based on total percentages:

GENDER	STUDENT MAJOR CATEGORIES A	C	M	Totals
Male	35.0%	22.5%	5.0%	62.5%
Female	15.0	15.0	7.5	37.5
Totals	50.0	37.5	12.5	100.0

Table based on row percentages:

GENDER	STUDENT MAJOR CATEGORIES A	C	M	Totals
Male	56.0%	36.0%	8.0%	100.0%
Female	40.0	40.0	20.0	100.0
Totals	50.0	37.5	12.5	100.0

Table based on column percentages;

GENDER	STUDENT MAJOR CATEGORIES A	C	M	Totals
Male	70.0%	60.0%	40.0%	62.5%
Female	30.0	40.0	60.0	37.5
Totals	100.0	100.0	100.0	100.0

2.8 (a) The percentages are 17.18, 5.21, 22.28, and 55.33. **(b)** More than half the oil consumed is from countries other than the U.S., Japan, and developed Europe. More than 20% is consumed by the U.S. and slightly less than 20% is consumed by developed Europe.

ENJOY SHOPPING FOR CLOTHING FOR YOURSELF	GENDER Male	Female	Total
Yes	20.15	25.69	45.84
No	29.78	24.38	54.16
Total	49.93	50.07	100.00

Table of column percentages

ENJOY SHOPPING FOR CLOTHING FOR YOURSELF	GENDER Male	Female	Total
Yes	40.35	51.31	45.84
No	59.65	48.69	54.16
Total	100	100	100

Table of row percentages

ENJOY SHOPPING FOR CLOTHING FOR YOURSELF	GENDER Male	Female	Total
Yes	43.95	56.05	100
No	54.99	45.01	100
Total	49.93	50.07	100

2.10 (a) Table of total percentages:
(b) Females are more prone to say yes than males.

2.12 The percentage of online retailers who require three or more clicks to be removed from an e-mail list has increased drastically from 2008 to 2009.

2.14 73 78 78 78 85 88.

2.16 (a) The boundaries are: 21.6 30.067 38.533 47 55.467 63.933 72.4 80.867 89.333 97.8 **(b)** 8.467 **(c)** 25.83, 34.30, 42.77, 51.23, 59.70, 68.17, 76.63, 85.10, 93.57.

2.18 (a)

Electricity Costs	Frequency	Percentage
$90 up to $99	3	7.5
$100 up to $119	6	15
$120 up to $139	5	12.5
$140 up to $159	11	27.5
$160 up to $179	7	17.5
$180 up to $199	5	12.5
$200 up to $219	3	7.5

(b)

Electricity Costs	Frequency	Percentage	Cumulative %
$ 99	3	7.5	7.5
$119	6	15	22.5
$139	5	12.5	35
$159	11	27.5	62.5
$179	7	17.5	80
$199	5	12.5	92.5
$219	3	7.5	100

(c) The majority of utility charges are clustered between $140 and $180.

2.20 (a)

Width	Frequency	Percentage
8.310–8.359	5	12.5
8.360–8.409	6	15
8.410–8.459	20	50
8.460–8.509	9	22.5
8.510–8.609	0	0

(b)

Width	Cumulative Frequency
8.310	12.5
8.360	27.5
8.410	77.5
8.460	100
8.510	100

(c) All the troughs will meet the company's requirements of between 8.31 and 8.61 inches wide.

2.22 (a) (b) Manufacturer A

Bulb Life (hrs)	Frequency	% Frequency	Cumulative %age freq.
650–749	3	10	10.00
750–849	5	16.67	26.67
850–949	20	66.67	93.33
950–1049	2	6.67	100.00
Total	30	100	

Manufacturer B

Bulb Life (hrs)	Frequency	% Frequency	Cumulative %age freq.
750–849	2	5	5.00
850–949	8	20	25.00
950–1049	16	40	65.00
1050–1149	9	22.5	87.50
1150–1249	5	12.5	100.00
Total	40	100	

(c) The bulbs produced by Manufacturer B have a longer life, as the cumulative percentages (less than type) are uniformly lower for B than for A.

2.24 (b) The Pareto chart is best for portraying these data because it not only sorts the frequencies in descending order but also provides the cumulative line on the same chart. **(c)** You can conclude that friends/family account for the largest percentage, 40%. When news media, online user reviews and other are added to friends/family, this accounts for 83%.

2.26 (b) 88%. **(d)** The Pareto chart allows you to see which sources account for most of the electricity.

2.28 (b) Since electricity consumption is spread over many types of appliances, a bar chart may be best in showing which types of appliances used the most electricity. **(c)** Clothes washers, air conditioning and lighting are the major categories of consumption.

2.30 (b) A higher percentage of females enjoy shopping for clothing.

2.32 The percentage of online retailers who require three or more clicks to be removed from an e-mail list has increased drastically from 2008 to 2009.

2.34 50 74 74 76 81 89 92.

2.36 (a)

Stem unit:	10	Stem unit:	10	Stem unit:	10
11	5	22	1 2 7 7	33	0 5
12	17	23		34	
13	2	24		35	
14	1	25	0	36	
15	1 8	26		37	
16	0 1 2 8	27		38	
17	0 2 3 8	28		39	
18	0 4	29		40	
19		30		41	
20	7 8	31	6		
21	2 6 7	32			

(b) The results are concentrated between $160 and $227.

2.38 (c) The majority of utility charges are clustered between $140 and $159.

2.40 The property taxes per capita appear to be right-skewed, with approximately 90% falling between $399 and $1,700 and the remaining 10% falling between $1,700 and $2,100. The center is at about $1,000.

2.42 (c) All the troughs will meet the company's requirements of between 8.31 and 8.61 inches wide.

2.44 No, the scatter does not show any pattern. There does not seem to be a relationship between *X* and *Y*.

2.46 (b) Yes, there is a strong positive relationship between *X* and *Y*. As *X* increases, so does *Y*.

2.48 (c) There appears to be very little relationship between the first weekend gross and either the U.S. gross or the worldwide gross of Harry Potter movies.

2.50 (a) and (c) There appears to be a positive relationship between the coaches' salary and revenue. Yes, this is borne out by the data.

2.52 (b) There is a great deal of variation in the returns from decade to decade. Most of the returns are between 5% and 15%. The 1950s, 1980s, and 1990s had exceptionally high returns, and only the 1930s and 2000s had negative returns.

2.54 (b) There has been a slight decline in movie attendance between 2001 and 2010. During that time, movie attendance increased from 2002 to 2004 but then decreased to a level below that in 2001.

2.56 (a)
(b) Although the ratio of fee-yes to fee-no bond funds for intermediate government category seems to be about 2-to-3 (19% to 31%), the ratio for above-average-risk intermediate government bond funds is closer to 1-to-1 (8.9% to 9.4%). While the group "intermediate government funds that do not charge a fee" has nearly equal numbers of above average risk, average risk, and below risk funds, the group "short term corporate bond funds that do not charge a fee" contains about 50% more below-average-risk funds than above-average-risk ones. The pattern of risk percentages differs between the fee-yes and fee-no funds in each of bond fund categories.
(c) The results for type, fee, and risk, in the two years are similar.

	A	B	C	D	E
1	**PivotTable of Type, Risk, and Fees**				
2					
3	Count of Type		Fees		
4	Type	Risk	No	Yes	Grand Total
5	⊟Intermediate Governmer	Above Average	9.44%	8.89%	18.33%
6		Average	10.56%	5.56%	16.11%
7		Below Average	10.56%	5.00%	15.56%
8	Intermediate Government Total		30.56%	19.44%	50.00%
9	⊟Short Term Corporate	Above Average	11.11%	2.78%	13.89%
10		Average	12.78%	4.44%	17.22%
11		Below Average	16.67%	2.22%	18.89%
12	Short Term Corporate Total		40.56%	9.44%	50.00%
13	Grand Total		71.11%	28.89%	100.00%

2.58 (a)

Count of Risk	Fees								
	No			No	Yes			Yes	Grand
Category	Average	High	Low	Total	Average	High	Low	Total	Total
Large cap	95	76	80	251	79	51	69	199	450
Mid-cap	33	41	23	97	22	45	10	77	174
Small cap	52	84	16	152	30	58	4	92	244
Grand Total	180	201	119	500	131	154	83	368	868

(b) Large-cap funds without fees are fairly evenly spread in risk, while large-cap funds with fees are more likely to have average or low risk. Mid-cap and small-cap funds, regardless of fees, are more likely to have average or high risk.

2.78 (c) Among the main categories as in (a), the publisher gets the largest portion of revenue, followed by the bookstore. When we consider the subcategories as well, as done in (b), manufacturing costs, followed by marketing and promotion and then author, gets the largest share of the revenues.

2.80 (b) The pie chart may be best since with only three categories, it enables you to see the portion of the whole in each category. **(d)** The pie chart may be best since, with only four categories it enables you to see the portion of the whole in each category. **(e)** The online content is not copy-edited or fact-checked as carefully as print content. Only 41% of the online content is copy-edited as carefully as print content and only 57% of the online content is fact-checked as carefully as the print content.

2.82 (a)

DESSERT ORDERED	GENDER: Male	Female	Total
Yes	29.41	70.59	100.00
No	53.03	46.97	100.00
Total	45.00	55.00	100.00

DESSERT ORDERED	GENDER: Male	Female	Total
Yes	22.22	43.64	34.00
No	77.78	56.36	66.00
Total	100.00	100.00	100.00

DESSERT ORDERED	GENDER: Male	Female	Total
Yes	10.00	24.00	34.00
No	35.00	31.00	66.00
Total	45.00	55.00	100.00

DESSERT ORDERED	BEEF ENTRÉE: Yes	No	Total
Yes	38.68	61.32	100.00
No	25.85	74.15	100.00
Total	29.25	70.75	100.00

DESSERT ORDERED	BEEF ENTRÉE: Yes	No	Total
Yes	35.04	22.97	26.50
No	64.96	77.03	73.50
Total	100.00	100.00	100.00

DESSERT ORDERED	BEEF ENTRÉE: Yes	No	Total
Yes	10.25	16.25	26.50
No	19.00	54.50	73.50
Total	29.25	70.75	100.00

(b) If the owner is interested in finding out the percentage of males and females who order dessert or the percentage of those who order a beef entrée and a dessert among all patrons, the table of total percentages is most informative. If the owner is interested in the effect of gender on ordering of dessert or the effect of ordering a beef entrée on the ordering of dessert, the table of column percentages will be most informative. Because dessert is usually ordered after the main entrée, and the owner has no direct control over the gender of patrons, the table of row percentages is not very useful here. **(c)** It is apparent from the column percentages that customers who order the beef entrée are more likely to order dessert.

2.84 (a) 23575R15 accounts for over 80% of the warranty claims. **(b)** 91.82% of the warranty claims are from the ATX model. **(c)** Tread separation accounts for 73.23% of the warranty claims among the ATX model. **(d)** The number of claims is evenly distributed among the three incidents; other/unknown incidents account for almost 40% of the claims, tread separation accounts for about 35% of the claims, and blowout accounts for about 25% of the claims.

2.86 (c) The alcohol percentage is concentrated between 4% and 6%, with the largest concentration between 4% and 5%. The calories are concentrated between 140 and 160. The carbohydrates are concentrated between 12 and 15. There are outliers in the percentage of alcohol in both tails. The outlier in the lower tail is due to the non-alcoholic beer O'Doul's with only a 0.4% alcohol content. There are a few beers with alcohol content as high as around 11.5%. There are a few beers with calorie content as high as 330 and carbohydrates as high as 32.1. There is a strong positive relationship between percentage alcohol and calories, and calories and carbohydrates and a moderately positive relationship between percentage alcohol and carbohydrates.

2.88 (c) The one-year CD rate is concentrated above 1.20. The five-year CD rate is concentrated between 2.2 and 2.5. In general, the five-year CD has the higher yield. There does not appear to be any relationship between the one-year CD rate and the five-year CD rate at the various banks.

2.90 (a) Frequency (Boston)

Weight (Boston)	Frequency	Percentage
3,015 but less than 3,050	2	0.54%
3,050 but less than 3,085	44	11.96
3,085 but less than 3,120	122	33.15
3,120 but less than 3,155	131	35.60
3,155 but less than 3,190	58	15.76
3,190 but less than 3,225	7	1.90
3,225 but less than 3,260	3	0.82
3,260 but less than 3,295	1	0.27

(b) Frequency (Vermont)

Weight (Vermont)	Frequency	Percentage
3,550 but less than 3,600	4	1.21%
3,600 but less than 3,650	31	9.39
3,650 but less than 3,700	115	34.85
3,700 but less than 3,750	131	39.70
3,750 but less than 3,800	36	10.91
3,800 but less than 3,850	12	3.64
3,850 but less than 3,900	1	0.30

(d) 0.54% of the Boston shingles pallets are underweight, and 0.27% are overweight. 1.21% of the Vermont shingles pallets are underweight, and 3.94% are overweight.

2.92 (c)

Calories	Frequency	Percentage	Limit	Percentage Less Than
50 but less than 100	3	12%	100	12%
100 but less than 150	3	12	150	24
150 but less than 200	9	36	200	60
200 but less than 250	6	24	250	84
250 but less than 300	3	12	300	96
300 but less than 350	0	0	350	96
350 but less than 400	1	4	400	100

Cholesterol	Frequency	Percentage	Limit	Percentage Less Than
0 but less than 50	2	8%	50	8%
50 but less than 100	17	68	100	76
100 but less than 150	4	16	150	92
150 but less than 200	1	4	200	96
200 but less than 250	0	0	250	96
250 but less than 300	0	0	300	96
300 but less than 350	0	0	350	96
350 but less than 400	0	0	400	96
400 but less than 450	0	0	450	96
450 but less than 500	1	4	500	100

The sampled fresh red meats, poultry, and fish vary from 98 to 397 calories per serving, with the highest concentration between 150 to 200 calories. One protein source, spareribs, with 397 calories, is more than 100 calories above the next-highest-caloric food. The protein content of the sampled foods varies from 16 to 33 grams, with 68% of the values falling between 24 and 32 grams. Spareribs and fried liver are both very different from other foods sampled—the former on calories and the latter on cholesterol content.

2.94 (b) There is a downward trend in the amount filled. **(c)** The amount filled in the next bottle will most likely be below 1.894 liter. **(d)** The scatter plot of the amount of soft drink filled against time reveals the trend of the data, whereas a histogram only provides information on the distribution of the data.

CHAPTER 3

3.2 (a) Mean $= 7.285715$, median $= 7$, mode $= 7$.
(b) Range $= 9$, $S^2 = 9.571429$, $S = 3.093773$, $CV = 42.46354\%$.
(c) Z scores: $-0.09235, -1.06204, 0.554109, -0.09235, -1.38527, 1.523798, 0.554109$. None of the Z scores are larger than 3.0 or smaller than 3.0 or smaller than -3.0. There is no outlier. **(d)** Since the mean is larger than the median, the distribution is right skewed.

3.4 (a) Mean $= -0.8$, median $= -5$, mode $=$ NA.
(b) Range $= 17$, $S^2 = 66.2$, $S = 8.136338$, $CV = -1017.04$.
(c) Z scores: $0.958662, -0.5162, -0.88492, -0.76201, 1.204473$. None of the Z scores is larger than 3.0 or smaller than -3.0. There is no outlier. **(d)** Since the mean is larger than the median, the distribution is right-skewed.

3.6

(a)

	Grade X	Grade Y
Mean	575.25	574.1667
Standard deviation	3.774917	2.639444

(b) If quality is measured by the average inner diameter, Grade X tires provide slightly better quality because X's mean is closer to the expected value, 575 mm. If, however, quality is measured by consistency, Grade Y provides better quality because, even though Y's mean is slightly larger than the mean for Grade X, Y's standard deviation is much smaller. The range in values for Grade Y is 7 mm compared to the range in values for Grade X, which is 8 mm.

(c)

	Grade X	Grade Y, Altered
Mean	575.25	574.8333
Standard deviation	3.774917	3.430258

When the sixth Y tire measures 570 mm rather than 578 mm, Y's mean inner diameter becomes 574.83 mm, which is closer to the norm than X's mean inner diameter, and Y's standard deviation increases from 2.64 mm to 3.43 mm, which is still less than that of X. So, in this case, Y's tires are providing better quality in terms of the mean inner diameter as well as less variation among the tires than X's.

3.8 (a) Mean $= 6.878$

Median $= 6.915$

(b) Standard deviation $= 1.774$

Range $= 5.67$

Coefficient of variation $= 25.795\%$

(c) The mean amount is lower than the median, so the data is left skewed.
(d) The mean cost is \$6.88 and the median cost is \$6.92. So there are few people spending very little on lunch which makes the range quite high.

3.10 (a) Mean = 19.53333333, median = 21, mode = 22. **(b)** S^2 = 33.6952, S = 5.80476, range = 25, coefficient of variation = 29.7172%, and Z scores are −0.09188, 0.424939, 0.424939, 1.114028, −0.09188, −0.09188, 0.597211, 0.769483, 0.252666, 0.252666, −3.19278, 0.424939, 0.424939, −0.6087. **(c)** Since the mean is less than the median, the data is left-skewed. **(d)** The distributions of MPG for sedans is right-skewed whereas that of the small SUVs is left-skewed. The mean MPG of sedans (27.214) is much higher than that of small SUVs (19.53). The median is slightly larger (24.5 for sedans and 21 for SUVs) and the modes are actually equal (22). The spread (in terms of SD and variance) is more for sedans but almost equal in terms of range. There is not any obvious outlier in MPG among the data for either type of cars.

3.12 (a) Mean = 0.894, median = 0.78. **(b)** Variance = 0.12476, standard deviation = 0.353213816, range = 0.96, CV = 39.50937542. There is no outlier because none of the Z scores has an absolute value that is greater than 3.0. **(c)** The mean cost is higher than the median, so the data is right skewed.

3.14 (a) Mean = 82.33333, median = 77. **(b)** Range = 48, variance = 327.0667, standard deviation = 18.08498 **(c)** The data is right skewed as median is less than mean. Spread is high, in terms of range as well as the variance The mean cost is higher than the median, so the data is right skewed. **(d) (a)** Mean = 99, median = 77. **(b)** Range = 148, variance = 3100.4, standard deviation = 55.68124. **(c)** With the change in data, the median is unaffected but the mean increases from 82 to 99. The range and variance has also jumped due to the introduction of this high outlier.

3.16 (a) Mean = 7.114667, median = 6.68. **(b)** Variance = 2.082189, standard deviation = 4.335512, range = 6.67, CV = 29.26615. **(c)** As the mean is higher than the median the data is right skewed. **(d)** Now the average and median waiting time are both higher than that for Bank A branch. The variability is also higher. Overall Bank A seems to be superior to B in respect of waiting time.

3.18 (a) 5.5, 9. 1.75. **(b)** 3, 5.5, 7, 9, 12. **(c)** The data is right-skewed as Q_1 is closer to the median than Q_3. **(d)** In Problem 3.2 (d), because mean = median, the distribution is symmetric. The box part of the graph is symmetric, but the tails show right-skewness.

3.20 (a) −7, 7, 7. **(b)** −8, −7, −5, 7, 9. **(c)** The data is right-skewed as Q_1 is closer to the median than Q_3. **(d)** The conclusions are similar in both cases.

3.22 (a) Q_1 = 0.5975, Q_3 = 1.085, interquartile range = 0.24375. **(b)** 0.55, 0.5975, 0.79, 1.085, 1.51. **(c)** The boxplot shows that the data is more concentrated below the median. The spread above the median is more. Spread, in terms of interquartile range, is quite high.

3.24 (a) Q_1 = 19, Q_3 = 22, interquartile range = 1.5. **(b)** 16, 19, 21, 22, 26. **(c)** The boxplot shows that the data is more concentrated above median and below the third-quartile. The spread below the median and above the first quartile is more. Spread, in terms of interquartile range, is quite low.

3.26 (a) Commercial district five-number summary: 0.38 3.2 4.5 5.55 6.46. Residential area five-number summary: 3.82 5.64 6.68 8.73 10.49. **(b)** Commercial district: The distribution is left-skewed. Residential area: The distribution is slightly right-skewed. **(c)** The central tendency of the waiting times for the bank branch located in the commercial district of a city is lower than that of the branch located in the residential area. There are a few long waiting times for the branch located in the residential area, whereas there are a few exceptionally short waiting times for the branch located in the commercial area.

3.28 (a)

Average of 3-Year Return	Risk			
Type	Above Average	Average	Below Average	Grand Total
Intermediate government	5.6515	5.7862	4.8214	5.4367
Short-term corporate	−0.0440	2.6355	3.2294	2.1156
Grand total	3.1966	4.1583	3.9484	3.7761

(b)

StdDev of 3-Year Return	Risk			
Type	Above Average	Average	Below Average	Grand Total
Intermediate government	2.4617	1.1457	1.2784	1.8066
Short-term corporate	3.6058	1.7034	1.4886	2.6803
Grand total	4.1197	2.1493	1.6001	2.8227

(c) Across the three different risk levels, intermediate government funds have the highest average three-year returns but the lowest standard deviation. **(d)** Similarly to the 2006–2008 three-year returns, intermediate government funds have the highest average three-year returns but the lowest standard deviation across the three different risk levels.

3.30 (a)

Average of Return 2008		Risk			
Type	Fees	Above Average	Average	Below Average	Grand Total
Intermediate government	No	9.0294	6.9053	4.0368	6.5709
	Yes	3.8863	7.1700	4.5444	4.9937
Intermediate government total		6.5358	6.99656	4.200	5.9576
Short-term corporate	No	10.7315	−1.6174	0.4600	−3.2607
	Yes	−10.2000	−1.6250	0.7250	−3.5941
Short-term corporate total		−10.6252	−1.6140	0.492	−3.3237
Grand total		−0.8612	2.5450	2.1661	1.316

(b)

StdDev of Return 2008		Risk			
Type	Fees	Above Average	Average	Below Average	Grand Total
Intermediate government	No	5.6635	3.6998	3.5178	4.7322
	Yes	6.5778	2.8744	3.2055	5.0712
Intermediate government total		6.5675	3.3870	3.3694	4.8999
Short-term corporate	No	8.6070	4.0613	3.3503	7.1587
	Yes	7.2928	5.4013	3.5790	6.9786
Short-term corporate total		8.2199	4.3480	3.3220	7.0874
Grand total		11.2319	5.8231	3.8020	7.6530

(c) The intermediate government funds have the highest average 2008 returns but the lowest standard deviation among all different combinations of risk level and whether there is a fee charged with the exception that they have the highest average 2008 returns and the highest standard deviation among the below average risk funds that do not charge a fee. **(d)** In contrast to the 2008 returns, the intermediate government funds have the lowest average 2009 returns for all combinations of risk level and whether the funds charged a fee with the except of the below average risk funds that do not charge a fee where the intermediate government funds have the highest average 2008 returns. Unlike the 2008 returns, the intermediate government funds have the lowest standard deviations only among the above average risk funds that do not charge a fee, the average risk funds that either charge a fee or do not charge a fee, and the below average risk funds that charge a fee.

3.32 (a) Population mean, $\mu = 5.916667$. **(b)** Population standard deviation, $\sigma = 1.656217$.

3.34 (a) 68%. **(b)** 95%. **(c)** Not calculable, 75%, 88.89%. **(d)** $\mu - 4\sigma$ to $\mu + 4\sigma$ or -2.8 to 19.2.

3.36 (a) Mean $= \frac{662{,}960}{51} = 12{,}999.22$, variance $= \frac{762{,}944{,}726.6}{51} = 14{,}959{,}700.52$, standard deviation $= \sqrt{14{,}959{,}700.52} = 3{,}867.78$. **(b)** 64.71%, 98.04%, and 100% of these states have mean per capita energy consumption within 1, 2, and 3 standard deviations of the mean, respectively. **(c)** This is consistent with 68%, 95%, and 99.7%, according to the empirical rule. **(d) (a)** Mean $= \frac{642{,}887}{50} = 12{,}857.74$, variance $= \frac{711{,}905{,}533.6}{50} = 14{,}238{,}110.67$, standard deviation $= \sqrt{14{,}238{,}110.67} = 3{,}773.34$. **(b)** 66%, 98%, and 100% of these states have a mean per capita energy consumption within 1, 2, and 3 standard deviations of the mean, respectively. **(c)** This is consistent with 68%, 95%, and 99.7%, according to the empirical rule.

3.38 (a) Covariance $= 59.35537$, coefficient of correlation $= 1$. **(b)** The relationship is perfectly collinear. $Y = 3X$ for this data, so the relationship is perfect.

3.40 (a) $\text{cov}(X, Y) = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{n - 1} = \frac{800}{6} = 133.3333$.

(b) $r = \frac{\text{cov}(X, Y)}{S_X S_Y} = \frac{133.3333}{(46.9042)(3.3877)} = 0.8391$.

(c) The correlation coefficient is more valuable for expressing the relationship between calories and sugar because it does not depend on the units used to measure calories and sugar. **(d)** There is a strong positive linear relationship between calories and sugar.

3.42 (a) $cov(X, Y) = 4{,}473{,}270.3$ **(b)** $r = 0.7903$ **(c)** There is a positive linear relationship between the coaches' salary and revenue.

3.56 (a) Mean $= 43.89$, median $= 45$, 1st quartile $= 18$, 3rd quartile $= 63$. **(b)** Range $= 76$, interquartile range $= 45$, variance $= 639.2564$, standard deviation $= 25.28$, $CV = 57.61\%$. **(c)** The distribution is right-skewed because there are a few policies that require an exceptionally long period to be approved. **(d)** The mean approval process takes 43.89 days, with 50% of the policies being approved in less than 45 days. 50% of the applications are approved between 18 and 63 days. About 67% of the applications are approved between 18.6 and 69.2 days.

3.58 (a) Mean $= 8.421$, median $= 8.42$, range $= 0.186$, $S = 0.0461$. The mean and median width are both 8.42 inches. The range of the widths is 0.186 inch, and the average scatter around the mean is 0.0461 inch. **(b)** 8.312, 8.404, 8.42, 8.459, 8.498. **(c)** Even though the mean = median, the left tail is slightly longer, so the distribution is slightly left-skewed. **(d)** All the troughs in this sample meet the specifications.

3.60 (a), (b)

	Calories	Fat
Mean	108.3333	3.375
Median	110	3.25
Standard deviation	19.4625	1.7597
Sample variance	378.7879	3.0966
Range	70	5.5
First quartile	90	1.5
Third quartile	120	5
Interquartile range	30	3.5
Coefficient of variation	17.97%	52.14%

(c) The distribution of calories and total fat are symmetrical.

(d) $r = \frac{\text{cov}(X, Y)}{S_X S_Y} = 0.6969$.

(e) The number of calories of the veggie burgers centers around 110, and its distribution is symmetrical. The amount of fat centers around 3.3 grams per serving, and its distribution is symmetrical. There is a positive linear relationship between calories and fat.

3.62 (a) Boston: 0.04, 0.17, 0.23, 0.32, 0.98; Vermont: 0.02, 0.13, 0.20, 0.28, 0.83. **(b)** Both distributions are right-skewed. **(c)** Both sets of shingles did quite well in achieving a granule loss of 0.8 gram or less. Only two Boston shingles had a granule loss greater than 0.8 gram. The next highest to these was 0.6 gram. These two values can be considered outliers. Only 1.176% of the shingles failed the specification. Only one of the Vermont shingles, had a granule loss greater than 0.8 gram. The next highest was 0.58 gram. Thus, only 0.714% of the shingles failed to meet the specification.

3.64 (a) The correlation between calories and protein is 0.4644. **(b)** The correlation between calories and cholesterol is 0.1777. **(c)** The correlation between protein and cholesterol is 0.1417. **(d)** There is a weak positive linear relationship between calories and protein, with a correlation coefficient of 0.46. The positive linear relationships between calories and cholesterol and between protein and cholesterol are very weak.

3.66 (a), (b)

Property Taxes per Capita ($)	
Mean	1,040.863
Median	981
Standard deviation	428.5385
Sample variance	183,645.2
Range	1,732
First quartile	713
Third quartile	1,306
Interquartile range	593
Coefficient of variation	41.17%

(c), (d) The distribution of the property taxes per capita is right-skewed, with a mean value of $1,040.83, a median of $981, and an average spread around the mean of $428.54. There is an outlier in the right tail at $2,099, while the standard deviation is about 41.17% of the mean. 25% of the states have property tax that falls below $713 per capita, and 25% have property taxes that are higher than $1,306 per capita.

CHAPTER 4

4.2 (a) Simple events include selecting a blue ball. **(b)** Selecting a blue ball. **(c)** The sample space consists of the 14 blue balls and the 7 yellow balls.

4.4 (a) $60/100 = 3/5 = 0.6$. **(b)** $10/100 = 1/10 = 0.1$. **(c)** $35/100 = 7/20 = 0.35$. **(d)** $9/10 = 0.9$.

4.6 (a) Mutually exclusive, not collectively exhaustive. **(b)** Not mutually exclusive, not collectively exhaustive. **(c)** Mutually exclusive, not collectively exhaustive. **(d)** Mutually exclusive, collectively exhaustive.

4.8 (a) Selection of a full-time employed student. **(b)** Selection of a full-time employed male student. **(c)** A full-time employed male student being or an unemployed male student. Yes, two characteristics are present here: being female and being employed full-time.

4.10 (a) A respondent who answers quickly. **(b)** A respondent who answers quickly who is over 70 years old. **(c)** A respondent who does not answer quickly. **(d)** A respondent who answers quickly and is over 70 years old is a joint event because it consists of two characteristics, answering quickly and being over 70 years old.

4.12 (a) $796/3{,}790 = 0.21$. **(b)** $1{,}895/3{,}790 = 0.50$. **(c)** $796/3{,}790 + 1{,}895/3{,}790 - 550/3{,}790 = 2{,}141/3790 = 0.5649$. **(d)** The probability of "is engaged with their workplace *or* is a U.S. worker" includes the probability of "is engaged with their workplace" plus the probability of "is a U.S. worker" minus the joint probability of "is engaged with their workplace *and* is a U.S. worker."

4.14 (a) 514/ 1,085. **(b)** 76/1,085. **(c)** 781/1,085 **(d)** $1{,}085/1{,}085 = 1.00$.

4.16 (a) $10/30 = 1/3 = 0.33$. **(b)** $20/60 = 1/3 = 0.33$. **(c)** $40/60 = 2/3 = 0.67$. **(d)** Because $P(A/B) = P(A) = 1/3$, events A and B are independent.

4.18 0.78.

4.20 Because $P(A \text{ and } B) = 0.2$ and $P(A)P(B) = 0.16$, events A and B are not independent.

4.22 (a) $536/1{,}000 = 0.536$. **(b)** $707/1{,}000 = 0.707$. **(c)** $P(\text{Answers quickly}) = 1{,}243/2{,}000 = 0.6215$ which is not equal to $P(\text{Answers quickly} \mid \text{between 12 and 50}) = 0.536$. Therefore, answers quickly and age are not independent.

4.24 (a) $550/1{,}895 = 0.2902$. **(b)** $1{,}345/1{,}895 = 0.7098$. **(c)** $246/1{,}895 = 0.1298$. **(d)** $1{,}649/1{,}895 = 0.8702$.

4.26 (a) $0.025/0.6 = 0.0417$. **(b)** $0.015/0.4 = 0.0375$. **(c)** Because $P(\text{Needs warranty repair} \mid \text{Manufacturer based in U.S.}) = 0.0417$ and $P(\text{Needs warranty repair}) = 0.04$, the two events are not independent.

4.28 (a) 0.0045. **(b)** 0.012. **(c)** 0.0059. **(d)** 0.0483.

4.30 0.1692

4.32 (a) 0.736. **(b)** 0.997.

4.34 (a) $P(B' \mid O) = \dfrac{(0.5)(0.3)}{(0.5)(0.3) + (0.25)(0.7)} = 0.4615.$

(b) $P(O) = 0.175 + 0.15 = 0.325$.

4.36 (a) $P(A) = 0.2041$. $P(B) = 0.3061$. $P(C) = 0.4898$. $P(\text{defective}) = P(\text{defective}|A)\,P(A) + P(\text{defective}|B)\,P(B) + P(\text{defective}|C)\,P(C) = (0.075)(0.2041) + (0.036)(0.3061) + (0.009)(0.4898) = 0.0307$.
(b) $P(B|\textit{defective}) = P(\textit{defective}|B)\,P(B)/P(\textit{defective}) = (0.036)(0.3061)/0.0307 = 0.3589$

4.38 $3^{10} = 59{,}049$.

4.40 3*3*5*5*4*6 = 5400

4.42 $(8)(4)(3)(3) = 288$.

4.44 $5! = (5)(4)(3)(2)(1) = 120$. Not all the orders are equally likely because the teams have a different probability of finishing first through fifth.

4.46 $n! = 6! = 720$.
4.48 56.

4.50 4,950.

4.60 (a)

	Age		
Goals	**18–25**	**26–40**	**Total**
Getting Rich	405	310	715
Other	95	190	285
Total	500	500	1,000

(b) Simple event: "Has a goal of getting rich." Joint event: "Has a goal of getting rich and is between 18–25 years old." **(c)** $P(\text{Has a goal of getting rich}) = 715/1{,}000 = 0.715$. **(d)** $P(\text{Has a goal of getting rich and is in the 26–40-year-old group}) = 310/1000 = 0.31$. **(e)** Not independent.

4.62 (a) 0.158. **(b)** 0.04. **(c)** 0.5587.

4.64 (a) 0.4712. **(b)** Because the probability that a fatality involved a rollover, given that the fatality involved an SUV, a van, or a pickup is 0.4712, which is almost twice the probability that a fatality involved a rollover with any vehicle type, at 0.24, SUVs, vans, and pickups are generally more prone to rollover accidents.

CHAPTER 5

5.2 (a) The expected number of television sets sold every day is 3.46. **(b)** Standard deviation = 1.5324.

5 .4 (a)

X	*P*(*X*)
$ − 1	21/36
$ + 1	15/36

(b)

X	*P*(*X*)
$ − 1	21/36
$ + 1	15/36

(c)

X	*P*(*X*)
$ − 1	30/36
$ + 4	6/36

(d) −$0.167 for each method of play.

5.6 (a) 3.56. **(b)** 3.17.

5.8 (a) $E(X) = \$66.20$; $E(Y) = \$63.01$. **(b)** $\sigma_X = \$57.22$; $\sigma_Y = \$195.22$. **(c)** Based on the expected value criteria, you would choose the common stock fund. However, the common stock fund also has a standard deviation more than three times higher than that for the corporate bond fund. An investor should carefully weigh the increased risk. **(d)** If you chose the common stock fund, you would need to assess your reaction to the small possibility that you could lose virtually all of your entire investment.

5.10 (a) 0.0466000. **(b)** 0.800154. **(c)** 0.009008.

5.12 (a) 0.000044. **(b)** 0.0049. **(c)** 0.8980. **(d)** 0.102.

5.14 (a) 0.0834. **(b)** 0.2351. **(c)** 0.6169. **(d)** 0.3831.

5.16 Given $\pi = 0.848$ and $n = 3$,

(a) $P(X = 3) = \dfrac{n!}{x!(n-x)!}\pi^x(1-\pi)^{n-x} = \dfrac{3!}{3!0!}(0.848)^3(0.152)^0 = 0.6098.$

(b) $P(X = 0) = \dfrac{n!}{x!(n-x)!}\pi^x(1-\pi)^{n-x} = \dfrac{3!}{0!3!}(0.848)^0(0.152)^3 = 0.0035.$

(c) $P(X \geq 2) = P(X = 2) + P(X = 3)$

$$= \frac{3!}{2!1!}(0.848)^2(0.152)^1 + \frac{3!}{3!0!}(0.848)^3(0.152)^0 = 0.9377.$$

(d) $E(X) = n\pi = 3(0.848) = 2.544$ $\sigma_X = \sqrt{n\pi(1-\pi)}$

$$= \sqrt{3(0.848)(0.152)} = 0.6218$$

5.18 (a) 0.354275. **(b)** 0.0470665. **(c)** 0.0008913. **(d)** 0.112599.

5.20 (a) 0.05213. **(b)** 0.02964. **(c)** 0.91823.

5.22 (a) $P(X < 5) = P(X = 0) + P(X = 1) + P(x = 2) + P(X = 3) + P(X = 4)$

$$= \frac{e^{-6}(6)^0}{0!} + \frac{e^{-6}(6)^1}{1!} + \frac{e^{-6}(6)^2}{2!} + \frac{e^{-6}(6)^3}{3!} + \frac{e^{-6}(6)^4}{4!}$$

$$= 0.002479 + 0.014873 + 0.044618 + 0.089235 + 0.133853$$

$$= 0.2851.$$

(b) $P(X = 5) = \frac{e^{-6}(6)^5}{5!} = 0.1606.$

(c) $P(X \geq 5) = 1 - P(X < 5) = 1 - 0.2851 = 0.7149.$

(d) $P(X = 4 \text{ or } X = 5) = P(X = 4) + P(X = 5) = \frac{e^{-6}(6)^4}{4!} + \frac{e^{-6}(6)^5}{5!}$

$$= 0.2945.$$

5.24 (a) $P(X = 0) = 0.0296$. **(b)** $P(X \geq 1) = 0.9704$. **(c)** $P(X \geq 2) = 0.8662$.

5.26 (a) 0.0458. **(b)** 0.74465. **(c)** 0.81974. **(d)** 288.

5.28 (a) 0.2618. **(b)** 0.8478. **(c)** Because Ford had a lower mean rate of problems per car in 2009 compared to Dodge, the probability of a randomly selected Ford having zero problems and the probability of no more than two problems are both higher than Dodge.

5.30 (a) 0.2441. **(b)** 0.8311. **(c)** Because Dodge had a lower mean rate of problems per car in 2009 compared to 2008, the probability of a randomly selected Dodge having zero problems and the probability of no more than two problems are both lower in 2009 than in 2008.

5.36 (a) 0.64. **(b)** 0.64. **(c)** 0.3020. **(d)** 0.0060. **(e)** The assumption of independence may not be true.

5.38 (a) If $\pi = 0.50$ and $n = 12$, $P(X \geq 9) = 0.0730$. **(b)** If $\pi = 0.75$ and $n = 12$, $P(X \geq 9) = 0.6488$.

5.40 (a) 0.3585. **(b)** 0.7358. **(c)** 0.2642. **(d)** 1. **(e)** There is a substantial reduction in the probability of defective parts in the batches of 20.

5.42 (a) $\mu = n\pi = 13.6$ **(b)** $\sigma = \sqrt{n\pi(1-\rho)} = 2.0861$. **(c)** $P(X = 15) = 0.1599$. **(d)** $P(X \leq 10) = 0.0719$. **(e)** $P(X \geq 10) = 0.9721$.

5.44 (a) If $\pi = 0.50$ and $n = 39$, $P(X \geq 34) = 0.00000121$. **(b)** If $\pi = 0.70$ and $n = 39$, $P(X \geq 34) = 0.0109$. **(c)** If $\pi = 0.90$ and $n = 39$, $P(X \geq 34) = 0.8097$. **(d)** Based on the results in (a)–(c), the probability that the Standard & Poor's 500 Index will increase if there is an early gain in the first five trading days of the year is very likely to be close to 0.90 because that yields a probability of 80.97% that at least 34 of the 39 years the Standard & Poor's 500 Index will increase the entire year.

5.46 (a) 0.001238. **(b)** 0.2552. **(c)** The mean number of buyers is 40. Standard deviation = 2.828.

CHAPTER 6

6.2 (a) 0.907347. **(b)** 0.092653. **(c)** 0.961. **(d)** −1.03944 and +1.03944.

6.4 (a) −1.28155. **(b)** 1.03643. **(c)** −0.818626. **(d)** 1.43953.

6.6 (a) 0.04779. **(b)** 16.1553. **(c)** 22.5249. **(d)** −23.451 and + 23.451.

6.8 (a) $P(34 < X < 50) = P(-1.33 < Z < 0) = 0.4082$. **(b)** $P(X < 30) + P(X > 60) = P(Z < -1.67) + P(Z > 0.83) = 0.0475 + (1.0 - 0.7967) = 0.2508$. **(c)** $P(Z < -0.84) \cong 0.20$, $Z = -0.84 = \frac{X - 50}{12}$, $X = 50 - 0.84(12) = 39.92$ thousand miles, or 39,920 miles. **(d)** The smaller standard deviation makes the absolute Z values larger. **(a)** $P(34 < X < 50) = P(-1.60 < Z < 0) = 0.4452$. **(b)** $P(X < 30) + P(X > 60) = P(Z < -2.00) + P(Z > 1.00) = 0.0228 + (1.0 - 0.8413) = 0.1815$. **(c)** $X = 50 - 0.84(10) = 41.6$ thousand miles, or 41,600 miles.

6.10 (a) 89.22%. **(b)** 0.6503. **(c)** 95.46. **(d)** The percentile value of 85 is 61.24, and the percentile value of 65 in the other exam is 95.22. Scoring 65 is better, and so Option 2 is better.

6.12 (a) 99.18%. **(b)** 78.74%. **(c)** 5.48%. **(d)** 0.9.

6.14 With 39 values, the smallest of the standard normal quantile values covers an area under the normal curve of 0.025. The corresponding Z value is −1.96. The middle (20th) value has a cumulative area of 0.50 and a corresponding Z value of 0.0. The largest of the standard normal quantile values covers an area under the normal curve of 0.975, and its corresponding Z value is +1.96.

6.16 (a) Mean = 21.12, median = 22, $S = 2.2971$, range = 10, $6S = 6(2.2971) = 13.7826$, interquartile range = 2.5, 1.33(2.2971) = 3.0551. The mean is slightly less than the median. The range is much less than $6S$, and the interquartile range is less than $1.33S$. **(b)** The normal probability plot does not appear to be highly skewed. The data may be symmetrical but not normally distributed.

6.18 (a) Mean = 1,040.863, median = 981, range = 1,732, $6(S) = 2{,}571.2310$, interquartile range = 593, $1.33(S) = 569.9562$. There are 62.75%, 78.43%, and 94.12% of the observations that fall within 1, 1.28, and 2 standard deviations of the mean, respectively, as compared to the approximate theoretical 66.67%, 80%, and 95%. Because the mean is slightly larger than the median, the interquartile range is slightly larger than 1.33 times the standard deviation, and the range is much smaller than 6 times the standard deviation, the data appear to deviate slightly from the normal distribution. **(b)** The normal probability plot suggests that the data appear to be slightly right-skewed.

6.20 (a) Interquartile range = 0.0025, $S = 0.0017$, range = 0.008, $1.33(S) = 0.0023$, $6(S) = 0.0102$. Because the interquartile range is close to $1.33S$ and the range is also close to $6S$, the data appear to be approximately normally distributed. **(b)** The normal probability plot suggests that the data appear to be approximately normally distributed.

6.22 (a) Five-number summary: 82 127 148.5 168 213; mean = 147.06, mode = 130, range = 131, interquartile range = 41, standard deviation = 31.69. The mean is very close to the median. The five-number summary suggests that the distribution is approximately symmetric around the median. The interquartile range is very close to $1.33S$. The range is about \$50 below $6S$. In general, the distribution of the data appears to closely resemble a normal distribution. **(b)** The normal probability plot confirms that the data appear to be approximately normally distributed.

6.30 (a) 0.4772. **(b)** 0.9544. **(c)** 0.0456. **(d)** 1.8835. **(e)** 1.8710 and 2.1290.

6.32 (a) 50%. **(b)** $P(749.97 \leq Y \leq 1330.03) = 50.49\%$. $P(763.34 \leq Y \leq 1336.66) = 50\%$. There is minor change in the limits.

6.34 (a) Waiting time will more closely resemble an exponential distribution. **(b)** Seating time will more closely resemble a normal distribution. **(c)** Both the histogram and normal probability plot suggest that waiting time more closely resembles an exponential distribution. **(d)** Both the histogram and normal probability plot suggest that seating time more closely resembles a normal distribution.

6.36 **(a)** 0.841345. **(b)** 0.873451. **(c)** 0.02275. **(d)** Top 90-th percentile of average user = 71.97. P(Y > 71.97) = 0.7638.

CHAPTER 7

7.2 Sample without replacement: Read from left to right in three-digit sequences and continue unfinished sequences from the end of the row to the beginning of the next row:
Row 05: 338 505 855 551 438 855 077 186 579 488 767 833 170
Rows 05–06: 897
Row 06: 340 033 648 847 204 334 639 193 639 411 095 924
Rows 06–07: 707
Row 07: 054 329 776 100 871 007 255 980 646 886 823 920 461
Row 08: 893 829 380 900 796 959 453 410 181 277 660 908 887
Rows 08–09: 237
Row 09: 818 721 426 714 050 785 223 801 670 353 362 449
Rows 09–10: 406
Note: All sequences above 902 and duplicates are discarded.

7.4 A simple random sample would be less practical for personal interviews because of travel costs (unless interviewees are paid to go to a central interviewing location).

7.6 Here all members of the population are equally likely to be selected, and the sample selection mechanism is based on chance. But selection of two elements is not independent; for example, if *A* is in the sample, we know that *B* is also and that *C* and *D* are not.

7.8 (a)

Row 16: 2323 6737 5131 8888 1718 0654 6832 4647 6510 4877
Row 17: 4579 4269 2615 1308 2455 7830 5550 5852 5514 7182
Row 18: 0989 3205 0514 2256 8514 4642 7567 8896 2977 8822
Row 19: 5438 2745 9891 4991 4523 6847 9276 8646 1628 3554
Row 20: 9475 0899 2337 0892 0048 8033 6945 9826 9403 6858
Row 21: 7029 7341 3553 1403 3340 4205 0823 4144 1048 2949
Row 22: 8515 7479 5432 9792 6575 5760 0408 8112 2507 3742
Row 23: 1110 0023 4012 8607 4697 9664 4894 3928 7072 5815
Row 24: 3687 1507 7530 5925 7143 1738 1688 5625 8533 5041
Row 25: 2391 3483 5763 3081 6090 5169 0546
Note: All sequences above 5,000 are discarded. There were no repeating sequences.

(b) 089 189 289 389 489 589 689 789 889 989
1089 1189 1289 1389 1489 1589 1689 1789 1889 1989
2089 2189 2289 2389 2489 2589 2689 2789 2889 2989
3089 3189 3289 3389 3489 3589 3689 3789 3889 3989
4089 4189 4289 4389 4489 4589 4689 4789 4889 4989
(c) With the single exception of invoice 0989, the invoices selected in the simple random sample are not the same as those selected in the systematic sample. It would be highly unlikely that a simple random sample would select the same units as a systematic sample.

7.10 Before accepting the results of a survey of college students, you might want to know, for example: Who funded the survey? Why was it conducted? What was the population from which the sample was selected? What sampling design was used? What mode of response was used: a personal interview, a telephone interview, or a mail survey? Were interviewers trained? Were survey questions field-tested? What questions were asked? Were the questions clear, accurate, unbiased, and valid? What operational definition of “vast majority” was used? What was the response rate? What was the sample size?

7.12 **(a)** The four types of survey errors are coverage error, nonresponse error, sampling error, and measurement error. **(b)** When people who answer the survey tell you what they think you want to hear, rather than what they really believe, this is the halo effect, which is a source of measurement error. Also, every survey will have sampling error that reflects the chance differences from sample to sample, based on the probability of particular individuals being selected in the particular sample.

7.14 Before accepting the results of the survey, you might want to know, for example: Who funded the study? Why was it conducted? What was the population from which the sample was selected? What sampling design was used? What mode of response was used: a personal interview, a telephone interview, or a mail survey? Were interviewers trained? Were survey questions field-tested? What other questions were asked? Were the questions clear, accurate, unbiased, and valid? What was the response rate? What was the margin of error? What was the sample size? What frame was used?

7.16 **(a)** 0.0272. **(b)** 0.2335. **(c)** 0.02012. **(d)** 0.65.

7.18 **(a)** Both means are equal to 6. This property is called unbiasedness. **(c)** The distribution for $n = 3$ has less variability. The larger sample size has resulted in sample means being closer to μ.

7.20 **(a)** When $n = 2$, because the mean is larger than the median, the distribution of the sales price of new houses is skewed to the right, and so is the sampling distribution of $\bar{X}$ although it will be less skewed than the population. **(b)** If you select samples of $n = 100$, the shape of the sampling distribution of the sample mean will be very close to a normal distribution, with a mean of \$272,400 and a standard deviation of \$9,000. **(c)** 0.9989. **(d)** 0.3611

7.22 **(a)** $P(\bar{X} \geq 30) = 0.04779$. **(b)** $P(\bar{X} \leq 29.0099) = 0.8$. **(c)** It is assumed that the average number of withdrawals follows a normal distribution. **(d)** $\bar{X} \sim N(28, \frac{6}{\sqrt{49}} = 0.8571), P(\bar{X} \leq 28.7214) = 0.8$.

7.24 **(a)** 0.25. **(b)** 0.05164.

7.26 **(a)** $\pi = 0.501, \sigma_p = \sqrt{\frac{\pi(1-\pi)}{n}} = \sqrt{\frac{0.501(1-0.501)}{100}} = 0.05$

$P(p > 0.55) = P(Z > 0.98) = 1.0 - 0.8365 = 0.1635.$

(b) $\pi = 0.60, \sigma_p = \sqrt{\frac{\pi(1-\pi)}{n}} = \sqrt{\frac{0.6(1-0.6)}{100}} = 0.04899.$

$P(p > 0.55) = P(Z > -1.021) = 1.0 - 0.1539 = 0.8461.$

(c) $\pi = 0.49, \sigma_p = \sqrt{\frac{\pi(1-\pi)}{n}} = \sqrt{\frac{0.49(1-0.49)}{100}} = 0.05$

$P(p > 0.55) = P(Z > 1.20) = 1.0 - 0.8849 = 0.1151.$

(d) Increasing the sample size by a factor of 4 decreases the standard error by a factor of 2.

(a) $P(p > 0.55) = P(Z > 1.96) = 1.0 - 0.9750 = 0.0250.$
(b) $P(p > 0.55) = P(Z > -2.04) = 1.0 - 0.0207 = 0.9793.$
(c) $P(p > 0.55) = P(Z > 2.40) = 1.0 - 0.9918 = 0.0082.$

7.28 **(a)** 0.0678. **(b)** 0.5856. **(c)** 0.0002. **(d)** **(a)** 0.1562. **(b)** 0.5020. **(c)** 0.009.

7.30 **(a)** 0.0013. **(b)** 0.0004. **(c)** $P(p > 0.8615) = 0.90$. Therefore, value $= 86$.

7.32 **(a)** 0.0336. **(b)** 0.0000. **(c)** Increasing the sample size by a factor of 5 decreases the standard error by a factor of $\sqrt{5}$. The sampling distribution of the proportion becomes more concentrated around the true proportion of 0.59 and, hence, the probability in (b) becomes smaller than that in (a).

7.44 **(a)** 0.433. **(b)** 0.7745. **(c)** 0.0013. **(d)** 0.1586. **(e)** 0.93.

7.46 (a) 0.9522. **(b)** 0.70. **(c)** 0.771.

7.48 (a) 0.5319. **(b)** 0.9538. **(c)** 0.9726.

CHAPTER 8

8.2 $119.12 \le \mu \le 130.88$.

8.4 Yes, it is true because 5% of intervals will not include the population mean.

8.6 (a) You would compute the mean first because you need the mean to compute the standard deviation. If you had a sample, you would compute the sample mean. If you had the population mean, you would compute the population standard deviation. **(b)** If you have a sample, you are computing the sample standard deviation, not the population standard deviation needed in Equation (8.1). If you have a population and have computed the population mean and population standard deviation, you don't need a confidence interval estimate of the population mean because you already know the mean.

8.8 Length $= 2\,Z \cdot \frac{\sigma}{\sqrt{n}} = 2 \times 1.95 \times \frac{\sigma}{\sqrt{100}} = 0.39\,\sigma$.

8.10 (a) $\bar{X} \pm Z \cdot \frac{\sigma}{\sqrt{n}} = 350 \pm 1.96 \cdot \frac{100}{\sqrt{64}}$; $325.50 \le \mu \le 374.50$. **(b)** No, the manufacturer cannot support a claim that the bulbs have a mean of 400 hours. Based on the data from the sample, a mean of 400 hours would represent a distance of 4 standard deviations above the sample mean of 350 hours. **(c)** No. Because σ is known and $n = 64$, from the Central Limit Theorem, you know that the sampling distribution of $\bar{X}$ is approximately normal. **(d)** The confidence interval is narrower, based on a population standard deviation of 80 hours rather than the original standard deviation of 100 hours. $\bar{X} \pm Z \cdot \frac{\sigma}{\sqrt{n}} = 350 \pm 1.96 \cdot \frac{80}{\sqrt{64}}$, $330.4 \le \mu \le 369.6$. Based on the smaller standard deviation, a mean of 400 hours would represent a distance of 5 standard deviations above the sample mean of 350 hours. No, the manufacturer cannot support a claim that the bulbs have a mean life of 400 hours.

8.12 (a) 2.3060. **(b)** 3.3554. **(c)** 2.0395. **(d)** 1.9977. **(e)** 1.8331.

8.14 $-1.599707192 \le \mu \le 13.26637386$, $1.53667182 \le \mu \le 5.46332818$. The outlier changes the mean and increases the standard deviation by a large amount and hence the length of the interval becomes very large.

8.16 (a) $32 \pm (2.0096)(9)/\sqrt{50}$; $29.44 \le \mu \le 34.56$ **(b)** The quality improvement team can be 95% confident that the population mean turnaround time is between 29.44 hours and 34.56 hours. **(c)** The project was a success because the initial turnaround time of 68 hours does not fall within the interval.

8.18 (a) $5.64 \le \mu \le 8.42$. **(b)** You can be 95% confident that the population mean amount spent for lunch at a fast-food restaurant is between $5.64 and $8.42.

8.20 (a)

interval $= \bar{X} \pm t \cdot \frac{S}{\sqrt{n}} = (19.1375913 \le \mu \le 22.32907537)$.

(b) The interval indicates that with a probability of 0.95, the MPG of small SUVs will lie between 19 and 22. **(c)** The results of 8.19 (a) and 8.20 (a) indicate that with 0.95 probability, the mileage of a family sedan will be more than that of a small SUV.

8.22 (a) $31.12 \le \mu \le 54.96$. **(b)** The number of days is approximately normally distributed. **(c)** No, the outliers skew the data. **(d)** Because the sample size is fairly large, at $n = 50$, the use of the t distribution is appropriate.

8.24 (a) $0.641321273 \le \mu \le 1.146678727$. **(b)** Assumption required is normality of the cost. **(c)** Using the answer to 3.12, the data is right skewed, so the assumption is not very justified here.

8.26 $0.263153 \le \pi \le 0.436847$.

8.28 (a) $p = \frac{X}{n} = \frac{135}{500} = 0.27$, $p \pm Z\sqrt{\frac{p(1-p)}{n}} = 0.27 \pm 2.58\sqrt{\frac{0.27(0.73)}{500}}$; $0.2189 \le \pi \le 0.3211$. **(b)** The manager in charge of promotional programs concerning residential customers can infer that the proportion of households that would purchase an additional telephone line if it were made available at a substantially reduced installation cost is somewhere between 0.22 and 0.32, with 99% confidence.

8.30 (a) $0.4762 \le \pi \le 0.5638$. **(b)** No, you cannot, because the interval estimate includes 0.50 (50%). **(c)** $0.5062 \le \pi \le 0.5338$. Yes, you can, because the interval is above 0.50 (50%). **(d)** The larger the sample size, the narrower the confidence interval, holding everything else constant.

8.32 (a) $0.784 \le \pi \le 0.816$. **(b)** $0.5099 \le \pi \le 0.5498$. **(c)** Many more people think that e-mail messages are easier to misinterpret.

8.34 $n = 27$.

8.36 $n = 601$.

8.38 (a) We require $1.96\frac{200}{\sqrt{n}} \le 20$, means $n \ge 384.16$. Use $n = 384$.

(b) We require $1.96\frac{200}{\sqrt{n}} \le 25$, which means $n \ge 245.86$. Use $n = 246$ employees.

8.40 $n = 385$.

8.42 (a) $n = 167$. **(b)** $n = 97$.

8.44 (a) $n = 246$. **(b)** $n = 385$. **(c)** $n = 554$. **(d)** When there is more variability in the population, a larger sample is needed to accurately estimate the mean.

8.46 (a) $p = 0.28$; $0.2522 \le \pi \le 0.3078$. **(b)** $p = 0.19$; $0.1657 \le \pi \le 0.2143$. **(c)** $p = 0.07$; $0.0542 \le \pi \le 0.0858$. **(d) (a)** $n = 1{,}937$. **(b)** $n = 1{,}479$. **(c)** $n = 626$.

8.48 (a) If you conducted a follow-up study to estimate the population proportion of individuals who view oil companies favorably, you would use $\pi = 0.84$ in the sample size formula because it is based on past information on the proportion. **(b)** $n = 574$.

8.54 The 99% confidence interval for average number of customers is $974 \pm 2.575\frac{52}{\sqrt{34}}$. Hence, $951.0363 \le \mu \le 996.9637$. So there is less than 1% chance of getting a daily count of less than 951. So the strategy seems to be effective.

8.56 (a) $14.085 \le \mu \le 16.515$. **(b)** $0.530 \le \pi \le 0.820$. **(c)** $n = 25$. **(d)** $n = 784$. **(e)** If a single sample were to be selected for both purposes, the larger of the two sample sizes ($n = 784$) should be used.

8.58 (a) $8.049 \le \mu \le 11.351$. **(b)** $0.284 \le \pi \le 0.676$. **(c)** $n = 35$. **(d)** $n = 121$. **(e)** If a single sample were to be selected for both purposes, the larger of the two sample sizes ($n = 121$) should be used.

8.60 (a) $\$25.80 \le \mu \le \$31.24$. **(b)** $0.3037 \le \pi \le 0.4963$. **(c)** $n = 97$. **(d)** $n = 423$. **(e)** If a single sample were to be selected for both purposes, the larger of the two sample sizes ($n = 423$) should be used.

8.62 (a) $\$36.66 \le \mu \le \$40.42$. **(b)** $0.2027 \le \pi \le 0.3973$. **(c)** $n = 110$. **(d)** $n = 423$. **(e)** If a single sample were to be selected for both purposes, the larger of the two sample sizes ($n = 423$) should be used.

8.64 (a) $n = 27$. **(b)** $\$1{,}581.24 \le \mu \le 1{,}727.30$.

8.66 (a) $8.41 \le \mu \le 8.43$. **(b)** With 95% confidence, the population mean width of troughs is somewhere between 8.41 and 8.43 inches.

(c) The assumption is valid as the width of the troughs is approximately normally distributed.

8.68 (a) $0.2425 \le \mu \le 0.2856$. **(b)** $0.1975 \le \mu \le 0.2385$. **(c)** The amounts of granule loss for both brands are skewed to the right, but the sample sizes are large enough. **(d)** Because the two confidence intervals do not overlap, you can conclude that the mean granule loss of Boston shingles is higher than that of Vermont shingles.

CHAPTER 9

9.2 $|1.21| < 1.96$ so H_0 is accepted.

9.4 Reject H_0 if $Z_{STAT} < -2.58$ or if $Z_{STAT} > 2.58$.

9.6 p-value $= 0.0456$.

9.8 p-value $= 0.1676$.

9.10 H_0: Defendant is guilty; H_1: Defendant is innocent. A Type I error would be not convicting a guilty person. A Type II error would be convicting an innocent person.

9.12 H_0: $\mu = 20$ minutes. 20 minutes is adequate travel time between classes. H_1: $\mu \neq 20$ minutes. 20 minutes is not adequate travel time between classes.

9.14 (a) (b) $Z = \dfrac{(360 - 375)}{\frac{50}{8}} = -2.4$ and p-value = 0.008 < 0.05. At the 5% level, there is evidence that the mean life is different from 375 hours. The p-value of 0.008 indicates that getting a value lower than -2.4 by chance from the null distribution has a 0.8% chance. **(c)** Interval = $\left(360 - 1.65\frac{50}{8}, 360 + 1.65\frac{50}{8}\right) = (349.6875, 370.3125)$. **(d)** As the 95% confidence interval does not include the target population mean (=375), the conclusion of (a) and (b) are validated.

9.16 (a) (b) $Z = \dfrac{(0.995 - 1.0)}{\frac{0.022}{7}} = -1.591$ and p-value = 0.0558 > 0.05. At the 5% level, there is no evidence that the mean amount is different from 1.0 gallon. The p-value of 0.0558 indicates that getting a value lower than -1.591 by chance from the null distribution has a 5.58% chance. **(c)** Interval $\left(1.0 - 1.65 = \frac{0.022}{7}, 1.0 + 1.65\frac{0.022}{7}\right) = (0.989814, 1.000186)$. **(d)** As the 95% confidence interval includes the target population mean (=1.0), the conclusion of (a) and (b) are validated.

9.18 $t_{STAT} = 4.00$.

9.20 ± 2.1315.

9.22 No, you should not use a t test because the original population is left-skewed, and the sample size is not large enough for the t test to be valid.

9.24 (a) H_0: $\mu = 3.7$ vs. H_1: $\mu \neq 3.7$. Decision rule: Reject H_0 if $|t\text{-stat}| > 2.0301$ d.f. $= 35$ Test statistic: $t = \dfrac{(3.57 - 3.7)}{\frac{0.8}{6}} = -0.975$. Decision: Since $|t\text{-stat}| < 2.0301$, do not reject H_0. There is not enough evidence to conclude that the population mean waiting time is different from 3.7 minutes at the 0.05 level of significance. **(b)** The sample size of 36 is large enough to apply the central limit theorem and, hence, you do not need to be concerned about the shape of the population distribution when conducting the t-test in (a).

9.26 (a) H_0: $\mu = 2.50$ vs. H_1: $\mu \neq 2.50$. Decision rule: H_0 if $|t\text{-stat}| > 1.9842$ d.f. $= 99$ Test statistic: $t = \dfrac{(2.55 - 2.50)}{\frac{0.14}{10}} = 3.571429$ p-value $= 0.00055$. Decision: Since $|t\text{-stat}| > 1.9842$ and the p-value of $0.00055 < 0.05$, we reject H_0. There is enough evidence to conclude that the mean retail value is different from \$2.50. **(b)** The p-value is 0.00055. If the population mean is indeed \$2.50, the probability of obtaining a sample mean that is more than \$0.14 away from \$2.50 is 0.00055.

9.28 (a) Because $-2.306 < t_{STAT} = 0.8754 < 2.306$, do not reject H_0. There is not enough evidence to conclude that the mean amount spent for lunch at a fast food restaurant, is different from \$6.50. **(b)** The p-value is 0.4069. If the population mean is \$6.50, the probability of observing a sample of nine customers that will result in a sample mean farther away from the hypothesized value than this sample is 0.4069. **(c)** The distribution of the amount spent is normally distributed. **(d)** With a small sample size, it is difficult to evaluate the assumption of normality. However, the distribution may be symmetric because the mean and the median are close in value.

9.30 (a) Since $|t\text{-}stat| < 2.68$ and the p-value of $0.91 > 0.01$ do not reject H_0. There is no evidence that the mean amount is different from 2 liters. **(b)** p-value $= 0.91$. **(d)** Yes, the data appear to have met the normality assumption. **(e)** The amount of fill is decreasing over time, so the pattern moves towards underweight bottles. The analysis is invalid since it didn't take the sequential nature of production into account.

9.32 (a) Because $t_{STAT} = -5.9355 < -2.0106$, reject H_0. There is enough evidence to conclude that mean widths of the troughs is different from 8.46 inches. **(b)** The population distribution is normal. **(c)** Although the distribution of the widths is left-skewed, the large sample size means that the validity of the t test is not seriously affected although the data is left skewed, the large sample size allows you to use the t distribution.

9.34 (a) The mean weight of the tea bags is exactly 5.50 grams so there is no evidence in favour of the amount being different from 5.5 grams at any level of significance. **(b)** There is a definite increasing pattern in the weight of the teabags, so the analysis gives a misleading picture regarding the tea-bag-filling operation which seems to be out of order.

9.36 p-value $= 0.0228$.

9.38 p-value $= 0.0838$.

9.40 p-value $= 0.9162$.

9.42 $t_{STAT} = 2.7638$.

9.44 $t_{STAT} = -2.5280$.

9.46 (a) $t_{STAT} = 0.0756 > 1.6766$. There is no evidence to conclude that the mean hours is less than 36.5 hours. **(b)** p-value $= 0.0756$. If the population mean is indeed 36.5, the probability of obtaining a sample mean that is more than 2 hours lower from 36.5 is 0.0756.

9.48 (a) $t_{STAT} = (32 - 68)/9/\sqrt{50} = -28.2843$. Because $t_{STAT} = -28.2843 < -2.4049$, reject H_0. p-value $= 0.0000 < 0.01$, reject H_0. **(b)** The probability of getting a sample mean of 32 minutes or less if the population mean is 68 minutes is 0.0000.

9.50 (a) H_0: $\mu \le 900$; H_1: $\mu > 900$. **(b)** A Type I error occurs when you conclude that the mean number of customers increased above 900 when in fact the mean number of customers is not greater than 900. A Type II error occurs when you conclude that the mean number of customers is not greater than 900 when in fact the mean number of customers has increased above 900. **(c)** Because $t_{STAT} = 4.4947 > 2.4448$ or p-value $= 0.0000 < 0.01$, reject H_0. There is enough evidence to conclude the population mean number of customers is greater than 900. **(d)** The probability that the sample mean is 900 customers or more when the null hypothesis is true is 0.0000.

9.52 $p = 0.44$.

9.54 Do not reject H_0.

9.56 (a) $Z_{STAT} = 1.4726$, p-value $= 0.0704$. Because $Z_{STAT} = 1.47 < 1.645$ or $0.0704 > 0.05$, do not reject H_0.

There is no evidence to show that more than 19.2% of students at your university use the Mozilla Foundation web browser. **(b)** $Z_{STAT} = 2.9451$, p-value $= 0016$. Because $Z_{STAT} = 2.9451 > 1.645$, reject H_0. There is evidence to show that more than 19.2% of students at your university use the Mozilla Foundation web browser. **(c)** The sample size had a major effect on being able to reject the null hypothesis. **(d)** You would be very unlikely to reject the null hypothesis with a sample of 20.

9.58 H_0: $\pi = 0.60$ vs. H_1: $\pi \neq 0.60$. Decision rule: Reject H_0 if $|Z_{STAT}| > 1.96$ or $p = 0.65$.

$$Z_{STAT} = \frac{(0.65 - 0.6)}{\sqrt{\dfrac{0.6(1 - 0.6)}{200}}} = 1.4434$$

Because $Z_{STAT} = 1.4434 < 1.96$, we accept H_0. There is no evidence to conclude that the proportion of students is different from 0.60.

9.60 (a) H_0: $\pi \leq 0.08$. No more than 8% of students at your school are omnivores. H_1: $\pi > 0.08$. More than 8% of students at your school are omnivores. **(b)** $Z_{STAT} = 3.6490 > 1.645$; p-value $= 0.0001316$. Because $Z_{STAT} = 3.6490 > 1.645$ or p-value $= 0.0001316 < 0.05$, reject H_0. There is enough evidence to show that the percentage of omnivores at your school is greater than 8%.

9.70 (a) Buying a site that is not profitable. **(b)** Not buying a profitable site. **(c)** Type I. **(d)** If the executives adopt a less stringent rejection criterion by buying sites for which the computer model predicts moderate or large profit, the probability of committing a Type I error will increase. Many more of the sites the computer model predicts that will generate moderate profit may end up not being profitable at all. On the other hand, the less stringent rejection criterion will lower the probability of committing a Type II error because more potentially profitable sites will be purchased.

9.72 (a) Because $t_{STAT} = 3.248 > 2.0010$, reject H_0. **(b)** p-value $= 0.0019$. **(c)** Because $Z_{STAT} = -0.32 > -1.645$, do not reject H_0. **(d)** Because $-2.0010 < t_{STAT} = 0.75 < 2.0010$, do not reject H_0. **(e)** Because $Z_{STAT} = -1.61 > -1.645$, do not reject H_0.

9.74 (a) Because $t_{STAT} = -1.69 > -1.7613$, do not reject H_0. **(b)** The data are from a population that is normally distributed. **(d)** With the exception of one extreme value, the data are approximately normally distributed. **(e)** There is insufficient evidence to state that the waiting time is less than five minutes.

9.76 (a) Because $t_{STAT} = -1.47 > -1.6896$, do not reject H_0. **(b)** p-value $= 0.0748$. If the null hypothesis is true, the probability of obtaining a t_{STAT} of -1.47 or more extreme is 0.0748. **(c)** Because $t_{STAT} = -3.10 < -1.6973$, reject H_0. **(d)** p-value $= 0.0021$. If the null hypothesis is true, the probability of obtaining a t_{STAT} of -3.10 or more extreme is 0.0021. **(e)** The data in the population are assumed to be normally distributed. **(g)** Both boxplots suggest that the data are skewed slightly to the right, more so for the Boston shingles. However, the very large sample sizes mean that the results of the t test are relatively insensitive to the departure from normality.

9.78 (a) $t_{STAT} = -21.61$, reject H_0. **(b)** p-value $= 0.0000$. **(c)** $t_{STAT} = -27.19$, reject H_0. **(d)** p-value $= 0.0000$. **(e)** Because of the large sample sizes, you do not need to be concerned with the normality assumption.

CHAPTER 10

10.2 (a) $t = 3.3075$. **(b)** $df = 18$. **(c)** 1.7341. **(d)** Because $t_{STAT} = 3.3075 > 1.7341$, reject H_0.

10.4 $0.9081 \leq \mu_1 - \mu_2 \leq 13.0919$.

10.6 $S_p^2 = \dfrac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)} = \dfrac{6 \cdot 4^2 + 3 \cdot 5^2}{6 + 3} = 19$ and $t_{STAT} = 2.5621 < 2.8214$. There is not enough evidence in favour of $\mu_1 > \mu_2$.

10.8 (a) Because $t_{STAT} = 5.7883 > 1.6581$ or p-value $= 0.0000 < 0.05$, reject H_0. There is evidence that the mean amount of Goldfish crackers eaten by children is higher for those who watched food ads than for those who did not watch food ads. **(b)** $5.79 \leq \mu_1 - \mu_2 \leq 11.81$. **(c)** The results cannot be compared because (a) is a one-tail test and (b) is a confidence interval that is comparable only to the results of a two-tail test.

10.10 (a) H_0: $\mu_1 = \mu_2$, where Populations: 1 = Males, 2 = Females. H_1: $\mu_1 \neq \mu_2$. Decision rule: $df = 170$. If $t_{STAT} < -1.974$ or $t_{STAT} > 1.974$, reject H_0.

Test statistic:

$$S_p^2 = \frac{(n_1 - 1)(S_1^2) + (n_2 - 1)(S_2^2)}{(n_1 - 1) + (n_2 - 1)} = \frac{(99)(13.35^2) + (71)(9.42^2)}{99 + 71} = 140.8489$$

$$t_{STAT} = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{S_p^2\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}} = \frac{(40.26 - 36.85) - 0}{\sqrt{140.8489\left(\dfrac{1}{100} + \dfrac{1}{72}\right)}} = 1.859.$$

Decision: Because $-1.974 < t_{STAT} = 1.859 < 1.974$, do not reject H_0. There is not enough evidence to conclude that the mean computer anxiety experienced by males and females is different. **(b)** p-value $= 0.0648$. **(c)** In order to use the pooled-variance t test, you need to assume that the populations are normally distributed with equal variances.

10.12 (a) Because $t_{STAT} = -4.1343 < -2.0484$, reject H_0. **(b)** p-value $= 0.0003$. **(c)** The populations of waiting times are approximately normally distributed. **(d)** $-4.2292 \leq \mu_1 - \mu_2 \leq -1.4268$.

10.14 (a) Because $|t_{STAT}| = 3.539 > 2.0345$, reject H_0. There is evidence of a difference in the mean surface hardness between untreated and treated steel plates. **(b)** p-value $= 0.0012$. This implies that obtaining an absolute difference as large as 9.06 by chance is very unlikely. **(c)** You need to assume that the population distribution of hardness of both untreated and treated steel plates is normally distributed. **(d)** Confidence interval = (2.063342, 16.06026).

10.16 (a) We test H_0: $\mu_1 = \mu_2$ against H_1: $\mu_1 \neq \mu_2$ The data is

$n_1 = 50$ $n_2 = 50$
$\bar{X}_1 = 121$ $\bar{X}_2 = 239$
$S_1 = 26.9$ $S_2 = 30.2$

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)} = 817.825$$

$$\text{d.f.} = 98,\ t_{STAT} = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_p\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}} = -20.631.$$

As $|t\text{-stat}| > 2.6269$, the critical value, we reject H_0. So there is evidence of a difference in the mean cell phone usage between the two age groups. **(b)** As the sample size from each population is large (more than 30), we do not need any other assumption.

10.18 $df = 19$.

10.20 (a) $t_{STAT} = \dfrac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_p\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}} - 1.4294$. Because $t_{STAT} = -1.4294 < 2.1448$, the critical value, we accept H_0. So there is not enough evidence of a difference in the mean ratings between the two brands. **(b)** You need to assume that the distribution of the differences between the two rations is approximately normal. **(c)** p-value $= 0.1626$. This implies that obtaining an absolute difference as large as 1.625 by chance has a 16% probability. **(d)** Confidence interval $= (\bar{X}_1 - \bar{X}_2) \pm tS_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}} = (-4.0633, 0.8133)$. So the first population's mean rating can be greater or less than the second.

10.22 (a) Because $-2.2622 < t_{STAT} = 0.0332 < 2.2622$ or p-value $= 0.9743 > 0.05$, do not reject H_0. There is not enough evidence to conclude that there is a difference between the mean prices between Costco and store brands. **(b)** You must assume that the distribution of the differences between the prices is approximately normal. **(c)** $-\$1.612 \le \mu_D \le \$1.66$. You are 95% confident that the mean difference between the prices is between $-\$1.612$ and \$1.66. **(d)** The results in (a) and (c) are the same. The hypothesized value of 0 for the difference in the price of shopping items between Costco and store brands is within the 95% confidence interval.

10.24 (a) Because $t_{STAT} = 1.8425 < 1.943$, do not reject H_0. There is not enough evidence to conclude that the mean bone marrow microvessel density is higher before the stem cell transplant than after the stem cell transplant. **(b)** p-value $= 0.0575$. The probability that the t statistic for the mean difference in microvessel density is 1.8425 or more is 5.75% if the mean density is not higher before the stem cell transplant than after the stem cell transplant. **(c)** $-28.26 \le \mu_D \le 200.55$. You are 95% confident that the mean difference in bone marrow microvessel density before and after the stem cell transplant is somewhere between -28.26 and 200.55. **(d)** that the distribution of the difference before and after the stem cell transplant is normally distributed.

10.26 (a) Because $t_{STAT} = -9.3721 < -2.4258$, reject H_0. There is evidence that the mean strength is lower at two days than at seven days. **(b)** The population of differences in strength is approximately normally distributed. **(c)** $p = 0.000$.

10.28 (a) Because $Z_{STAT} = -0.3467$ is below the critical bound of 2.575, do not reject H_0. **(b)** $-0.19418 \le \pi_1 - \pi_2 \le 0.134184$.

10.30 (a) H_0: $\pi_1 \le \pi_2$. H_1: $\pi_1 > \pi_2$. Populations: $1 = 2009$, $2 = 2008$. **(b)** Because $Z_{STAT} = 4.70472 > 1.645$ reject H_0. There is sufficient evidence to conclude that the population proportion of large online retailers who require three or more clicks to be removed from an e-mail list is greater in 2009 than in 2008. **(c)** Yes, the result in (b) makes it appropriate to claim that the population proportion of large online retailers who require three or more clicks to be removed from an e-mail list is greater in 2009 than in 2008.

10.32 (a) H_0: $\pi_1 = \pi_2$. H_1: $\pi_1 \ne \pi_2$. Decision rule: If $|Z_{STAT}| > 2.58$, reject H_0.

Test statistic: $\bar{p} = \dfrac{X_1 + X_2}{n_1 + n_2} = \dfrac{707 + 536}{1{,}000 + 1{,}000} = 0.6215$

$$Z_{STAT} = \frac{(p_1 - p_2) - (\pi_2 - \pi_2)}{\sqrt{\bar{p}(1-\bar{p})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{(0.707 - 0.536) - 0}{\sqrt{0.6215(1 - 0.6215)\left(\frac{1}{1{,}000} + \frac{1}{1{,}000}\right)}}.$$

$Z_{STAT} = 7.8837 > 2.58$, reject H_0. There is evidence of a difference in the proportion who believe that e-mail messages should be answered quickly between the two age groups. **(b)** p-value $= 0.0000$. The probability of obtaining a difference in proportions that gives rise to a test statistic below -7.8837 or above $+7.8837$ is 0.0000 if there is no difference in the proportion of people in the two age groups who believe that e-mail messages should be answered quickly.

10.34 (a) Because $Z_{STAT} = 7.2742 > 1.96$, reject H_0. There is evidence of a difference in the proportion of adults and users ages 12–17 who oppose ads. **(b)** p-value $= 0.0000$. The probability of obtaining a difference in proportions that is 0.16 or more in either direction is 0.0000 if there is no difference between the proportion of adults and users ages 12–17 who oppose ads.

10.36 (a) 2.21. **(b)** 2.48 **(c)** 3.55.

10.38 (a) Population B: $S^2 = 25$. **(b)** 1.7857.

10.40 $df_{\text{numerator}} = 24$, $df_{\text{denominator}} = 20$.

10.42 Because F_{STAT} is less than F critical, do not reject H_0.

10.44 (a) Since $F_{STAT} = 1.5064 < 3.09$, do not reject H_0. **(b)** F critical $= 3.83$. We accept H_0.

10.46 (a) H_0: $\sigma_1^2 = \sigma_2^2$. H_1: $\sigma_1^2 \ne \sigma_2^2$.

Decision rule: If $F_{STAT} > 1.556$, reject H_0.

Test statistic: $F_{STAT} = \dfrac{S_1^2}{S_2^2} = \dfrac{(13.35)^2}{(9.42)^2} = 2.008$.

Decision: Because $F_{STAT} = 2.008 > 1.556$, reject H_0. There is evidence to conclude that the two population variances are different. **(b)** p-value $= 0.0022$. **(c)** The test assumes that each of the two populations is normally distributed. **(d)** Based on (a) and (b), a separate-variance t test should be used.

10.48 (a) Because $F_{STAT} = 5.1802 > 2.34$ or p-value $= 0.0002 < 0.05$, reject H_0. There is evidence of a difference in the variability of the battery life between the two types of digital cameras. **(b)** p-value $= 0.0002$. The probability of obtaining a sample that yields a test statistic more extreme than 5.1802 is 0.0002 if there is no difference in the two population variances. **(c)** The test assumes that each of the two populations are normally distributed. **(d)** Based on (a) and (b), a separate-variance t test should be used.

10.50 Because $F_{STAT} = 2.7684 > 2.2693$, or p-value $= 0.0156 < 0.05$, reject H_0. There is evidence of a difference in the variance of the yield at the two time periods.

10.52 (a) $SSW = 120$. **(b)** $MSA = 23.33$. **(c)** $MSW = 4.286$. **(d)** $F_{STAT} = 5.44$.

10.54 (a) 3. **(b)** 20. **(c)** 23.

10.56 (a) Reject H_0 if $F_{STAT} > 4.94$. **(b)** Because $F_{STAT} = 2.86 < 4.94$, accept H_0. **(c)** There are $c = 4$ degrees of freedom in the numerator and $n - c = 24 - 4 = 20$ degrees of freedom in the denominator. The critical value is, $Q_u = 3.96$. **(d)** To perform the Tukey-Kramer procedure, the critical range is 8.55.

10.58 (a) H_0: $\mu_A = \mu_B = \mu_C = \mu_D$ and H_1: At least one mean is different.

$$MSA = \frac{SSA}{c-1} = \frac{1{,}986.475}{3} = 662.1583.$$

$$MSW = \frac{SSW}{n-c} = \frac{495.5}{36} = 13.76389.$$

$$F_{STAT} = \frac{MSA}{MSW} = \frac{662.1583}{13.76389} = 48.1084.$$

$$F_{0.05,3,36} = 2.8663.$$

Because the p-value is approximately 0 and $F_{STAT} = 48.1084 > 2.8663$, reject H_0. There is sufficient evidence of a difference in the mean strength of the four brands of trash bags.

(b) Critical range $= Q_\alpha\sqrt{\dfrac{MSW}{2}\left(\dfrac{1}{n_j} + \dfrac{1}{n_{j'}}\right)} = 3.79\sqrt{\dfrac{13.7639}{2}\left(\dfrac{1}{10} + \dfrac{1}{10}\right)}$

$= 4.446$.

From the Tukey-Kramer procedure, there is a difference in mean strength between Kroger and Tuffstuff, Glad and Tuffstuff, and Hefty and Tuffstuff. **(c)** ANOVA output for Levene's test for homogeneity of variance:

$$MSA = \frac{SSA}{c-1} = \frac{24.075}{3} = 8.025.$$

$$MSW = \frac{SSW}{n-c} = \frac{198.2}{36} = 5.5056.$$

$$F_{STAT} = \frac{MSA}{MSW} = \frac{8.025}{5.5056} = 1.4576.$$
$$F_{0.05,3,36} = 2.8663.$$

Because p-value $= 0.2423 > 0.05$ and $F_{STAT} = 1.4576 < 2.8663$, do not reject H_0. There is insufficient evidence to conclude that the variances in strength among the four brands of trash bags are different. **(d)** From the results in (a) and (b), Tuffstuff has the lowest mean strength and should be avoided.

10.60 (a) Because $F_{STAT} = 12.56 > 2.76$, reject H_0. **(b)** Critical range $=$ 4.67. Advertisements A and B are different from Advertisements C and D. Advertisement E is only different from Advertisement D. **(c)** Because $F_{STAT} = 1.927 < 2.76$, do not reject H_0. There is no evidence of a significant difference in the variation in the ratings among the five advertisements. **(d)** The advertisements underselling the pen's characteristics had the highest mean ratings, and the advertisements overselling the pen's characteristics had the lowest mean ratings. Therefore, use an advertisement that undersells the pen's characteristics and avoid advertisements that oversell the pen's characteristics.

10.62 (a) Because the p-value for this test, 0.922, is greater than the level of significance, $\alpha = 0.05$ (or the computed F test statistic, 0.0817, is less than the critical value $F = 3.6823$), you cannot reject the null hypothesis. You conclude that there is insufficient evidence of a difference in the mean yield between the three methods used in the cleansing step. **(b)** Because there is no evidence of a difference between the methods, you should not develop any multiple comparisons. **(c)** Because the p-value for this test, 0.8429, is greater than the level of significance, $\alpha = 0.05$ (or the computed F test statistic, 0.1728, is less than the critical value, $F = 3.6823$), you cannot reject the null hypothesis. You conclude that there is insufficient evidence of a difference in the variation in the yield between the three methods used in the cleansing step. **(d)** Because there is no evidence of a difference in the variation between the methods, the validity of the conclusion reached in (a) is not affected.

10.64 (a) Because $F_{STAT} = 53.03 > 2.92$, reject H_0. **(b)** Critical range $= 5.27$ (using 30 degrees of freedom). Designs 3 and 4 are different from Designs 1 and 2. Designs 1 and 2 are different from each other. **(c)** The assumptions are that the samples are randomly and independently selected (or randomly assigned), the original populations of distances are approximately normally distributed, and the variances are equal. **(d)** Because $F_{STAT} = 2.093 < 2.92$, do not reject H_0. There is no evidence of a significant difference in the variation in the distance among the four designs. **(e)** The manager should choose Design 3 or 4.

10.76 (a) \$0.59 coffee: $t_{STAT} = 2.8167 > 1.7613$ (or p-value $= 0.0069 < 0.05$), so reject H_0. There is evidence that reducing the price to \$0.59 has increased mean daily customer count. \$0.79 coffee: $t_{STAT} = 2.0894 > 1.7613$ (or p-value $= 0.0277 < 0.05$), so reject H_0. There is evidence that reducing the price to \$0.79 has increased mean daily customer count. **(b)** Because $F_{STAT} = 1.3407 < 2.9786$, or p-value $= 0.5906 > 0.05$, do not reject H_0. There is not enough evidence of a difference in the variance of the daily customer count for \$0.59 and \$0.79 coffee. Because $-2.0484 < t_{STAT} = 0.7661 < 2.0484$ or p-value $= 0.4500 > 0.05$, do not reject H_0. There is insufficient evidence of a difference in the mean daily customer count for \$0.59 and \$0.79 coffee. **(c)** Since both \$0.59 and \$0.79 coffee increased daily customer count, you should recommend that the price of coffee should be reduced. However, since there is no significant difference in the mean daily customer count between the two prices, you should price the coffee at \$0.79 per 12-ounce cup.

10.78 (a) We test H_0: $\sigma_G^2 = \sigma_B^2$, $F = 29000^2/26466^2 = 1.2 < 2.3 =$ critical value $F_{15,86}$. So there is no difference in the variability of salaries between master black belts and green belts. **(b)** As the variabilities are equal, a pooled-variance t test is appropriate. **(c)** We test H_0: $\mu_G^2 = \mu_B^2$ vs. H_0: $\mu_G^2 < \mu_B^2$. The pooled variance one sided $t_{STAT} = -4.97 < -2.36$, the critical t value. So we reject H_0. There is evidence that the mean salary of master black belts is greater than the mean salary of green belts.

10.80 (a) We test H_0: $\mu_W^2 = \sigma_E^2$, $F = 10.56 > 1.6 = F_{92,119}$. So there is evidence of a difference in the variances of the age of students at the western school and at the eastern school. **(b)** The result in (a) implies that one has to use the unequal variance test procedure. **(c)** It is more appropriate to use separate-variance t-test. **(d)** $F = 1.22 < 1.63 = F_{119,92}$. There is no evidence of a difference in the variances of the years of spreadsheet usage of students at the Western school and at the Eastern school. **(e)** As variances are equal, we use the pooled-variance t-test. $t_{STAT} = -5.747 < -2.6$, so reject H_0. There is enough evidence of a difference in the mean years of spreadsheet usage of students at the Western school and at the Eastern school.

10.82 (a) Because $t_{STAT} = 3.3282 > 1.8595$, reject H_0. There is enough evidence to conclude that the introductory computer students required more than a mean of 10 minutes to write and run a program in Visual Basic. **(b)** Because $t_{STAT} = 1.3636 < 1.8595$, do not reject H_0. There is not enough evidence to conclude that the introductory computer students required more than a mean of 10 minutes to write and run a program in Visual Basic. **(c)** Although the mean time necessary to complete the assignment increased from 12 to 16 minutes as a result of the increase in one data value, the standard deviation went from 1.8 to 13.2, which reduced the value of t statistic. **(d)** Because $F_{STAT} = 1.2308 < 3.8549$, do not reject H_0. There is not enough evidence to conclude that the population variances are different for the Introduction to Computers students and computer majors. Hence, the pooled-variance t test is a valid test to determine whether computer majors can write a Visual Basic program in less time than introductory students, assuming that the distributions of the time needed to write a Visual Basic program for both the Introduction to Computers students and the computer majors are approximately normally distributed. Because $t_{STAT} = 4.0666 > 1.7341$, reject H_0. There is enough evidence that the mean time is higher for Introduction to Computers students than for computer majors. **(e)** p-value $= 0.000362$. If the true population mean amount of time needed for Introduction to Computer students to write a Visual Basic program is no more than 10 minutes, the probability of observing a sample mean greater than the 12 minutes in the current sample is 0.0362%. Hence, at a 5% level of significance, you can conclude that the population mean amount of time needed for Introduction to Computer students to write a Visual Basic program is more than 10 minutes. As illustrated in part **(d)**, in which there is not enough evidence to conclude that the population variances are different for the Introduction to Computers students and computer majors, the pooled-variance t test performed is a valid test to determine whether computer majors can write a Visual Basic program in less time than introductory students, assuming that the distribution of the time needed to write a Visual Basic program for both the Introduction to Computers students and the computer majors are approximately normally distributed.

10.84 From the boxplot and the summary statistics, both distributions are approximately normally distributed. $F_{STAT} = 1.056 < 1.89$. There is insufficient evidence to conclude that the two population variances are significantly different at the 5% level of significance. $t_{STAT} = -5.084 < -1.99$. At the 5% level of significance, there is sufficient evidence to reject the null hypothesis of no difference in the mean life of the bulbs between the two manufacturers. You can conclude that there is a significant difference in the mean life of the bulbs between the two manufacturers.

10.86 Playing a game on a video game system: Because $Z_{STAT} = 15.74 > 1.96$ and p-value $= 0.0000 < 0.05$, reject H_0. There is evidence that there is a difference between boys and girls in the proportion who played a game on a video game system. Reading a book for fun: Because $Z_{STAT} = -2.1005 < -1.96$ and p-value $= 0.0357 < 0.05$, reject H_0. There is evidence that there is a difference between boys and girls in the proportion who have read a book for fun. Gave product advice to parents: Because $-1.96 < Z_{STAT} = 0.7427 < 1.96$ and p-value $= 0.4576 > 0.05$, do not reject H_0. There is insufficient evidence that there is a difference between boys and girls in the proportion who gave product advice to parents. Shopped at a mall: Because $Z_{STAT} = -6.7026 < -1.96$ and p-value $= 0.0000 < 0.05$, reject H_0. There is evidence that there is a difference between boys and girls in the proportion who shopped at a mall.

10.88 The normal probability plots suggest that the two populations are not normally distributed. An F test is inappropriate for testing the difference in two variances. The sample variances for Boston and Vermont shingles are 0.0203 and 0.015, respectively. Because $t_{STAT} = 3.015 > 1.967$ or p-value $= 0.0028 < \alpha = 0.05$, reject H_0. There is sufficient evidence to conclude that there is a difference in the mean granule loss of Boston and Vermont shingles.

10.90 Population 1 = foreign large-cap blend, 2 = small-cap blend, 3 = mid-cap blend, 4 = Large-cap blend, 5 = diversified emerging markets; Three-year return: Levene test: $F_{STAT} = 0.4148$. Since the p-value $= 0.7971 > 0.05$, do not reject H_0. There is insufficient evidence to show a difference in the variance of the three-year return among the 5 different types of mutual funds at a 5% level of significance. $F_{STAT} = 14.3127$. Since the p-value is virtually zero, reject H_0. There is sufficient evidence to show a difference in the mean three-year returns among the five different types of mutual funds at a 5% level of significance. Critical range = 2.83. Groups 3 and 4. (Mid-cap blend and large-cap blend) have lower three-year returns than diversified emerging markets. All other comparisons are not significant. Five-year return: Levene test: $F_{STAT} = 0.9671$. Since the p-value $= 0.4349 > 0.05$, do not reject H_0. There is insufficient evidence to show a difference in the variance of the five-year return among the 5 different types of mutual funds at a 5% level of significance. $F_{STAT} = 62.4531$ Since the p-value is virtually zero, reject H_0. There is sufficient evidence to show a difference in the mean five-year returns among the five different types of mutual funds at a 5% level of significance. Critical range = 2.3171. At the 5% level of significance, there is sufficient evidence that the mean five-year returns of the diversified emerging market funds is significantly higher than the others. Also, the mean five-year returns of the large-cap blend funds are significantly lower than that of the foreign large-cap funds. Ten-year return: Levene test: $F_{STAT} = 0.7854$. Since the p-value $= 0.5407 > 0.05$, do not reject H_0. There is insufficient evidence to show a difference in the variance of return among the five different types of mutual funds at a 5% level of significance. $F_{STAT} = 11.9951$. Since the p-value is virtually zero, reject H_0. There is sufficient evidence to show a difference in the mean 10-year returns among the five different types of mutual funds at a 5% level of significance. Critical range = 3.3372. At the 5% level of significance, there is sufficient evidence that the mean 10-year returns of the diversified emerging market funds is significantly higher than the others. Expense ratio: Levene test: $F_{STAT} = 0.59$. Since the p-value $= 0.6716 > 0.05$, do not reject H_0. There is insufficient evidence to show a difference in the variance in expense ratios among the 5 different types of mutual funds at a 5% level of significance. $F_{STAT} = 4.1069$. Since the p-value $= 0.0064 < 0.05$, reject H_0. There is sufficient evidence to show a difference in the mean expense ratio among the five different types of mutual funds at a 5% level of significance. Critical range = 0.479. At the 5% level of significance, there is sufficient evidence that the mean expense ratio of the diversified emerging market funds is significantly higher than the foreign large-cap funds.

CHAPTER 11

11.2 (a) For $df = 1$ and $\alpha = 0.05$, $\chi^2_\alpha = 2.072251$. **(b)** For $df = 1$ and $\alpha = 0.025$, $\chi^2 = 2.705543$.

11.4 (a) All $f_e = 37.5$. **(b)** $\chi^2_{STAT} = 0.6667$. At $\alpha = 0.1$, $\chi^2_1 = 2.70$. Not significant.

11.6 (b) Because $\chi^2_{STAT} = 28.9102 > 3.841$, reject H_0. There is enough evidence to conclude that there is a significant difference between the proportion of retail websites that require three or more clicks to be removed from an email list in 2009 as compared to 2008. p-value = 0.0000. The probability of obtaining a test statistic of 28.9102 or larger when the null hypothesis is true is 0.0000. **(c)** You should not compare the results in (a) to those of Problem 10.30 (b) because that was a one-tail test.

11.8 (a) H_0: $\pi_1 = \pi_2$. H_1: $\pi_1 \neq \pi_2$. Because $\chi^2_{STAT} = (536 - 621.5)^2/621.5 + (464 - 378.5)^2/378.5 + (707 - 621.5)^2/621.5 + (293 - 378.5)^2/378.5 = 62.152 > 6.635$, reject H_0. There is evidence of a difference in the proportion who believe that e-mail messages should be answered quickly between the two age groups. **(b)** p-value = 0.0000. The probability of obtaining a difference in proportions that gives rise to a test statistic greater than 62.152 is 0.0000 if there is no difference in the proportion of people in the two age groups who believe that e-mail messages should be answered quickly. **(c)** The results of (a) and (b) are exactly the same as those of Problem 10.32. The χ^2 in (a) and the Z in Problem 10.32 (a) satisfy the relationship that $\chi^2 = 62.152 = Z^2 = (7.8837)^2$, and the p-value in (b) is exactly the same as the p-value computed in Problem 10.32 (b).

11.10 (a) Since $\chi^2_{STAT} = 52.9144 > 3.841$, reject H_0. There is evidence that there is a significant difference between the proportion of adults and users ages 12–17 who oppose ads on websites. **(b)** p-value 0.0000. The probability of obtaining a test statistic of 52.9144 or larger when the null hypothesis is true is 0.0000.

11.12 (a) The expected frequencies for the first row are 22.46, 31.45, 44.93, and 56.16. The expected frequencies for the second row are 27.54, 38.55, 55.07, and 68.84. **(b)** Chi-Sq = 6.141, DF = 3, p-value = 0.105. Since the p-value is less than 0.05, the test is not significant at that level.

11.14 (a) Because the calculated test statistic $\chi^2_{STAT} = 48.6268 > 9.4877$, reject H_0 and conclude that there is a difference in the proportion who oppose ads on websites between the age groups. **(b)** The p-value is virtually 0. The probability of a test statistic greater than 48.6268 or more is approximately 0 if there is no difference between the age groups in the proportion who oppose ads on websites.

11.16 (a) H_0: $\pi_1 = \pi_2 = \pi_3$. H_1: At least one proportion differs.

f_0	f_e	$(f_0 - f_e)$	$(f_0 - f_e)^2/f_e$
48	42.667	5.333	0.667
152	157.333	−5.333	0.181
56	42.667	13.333	4.166
144	157.333	−13.333	1.130
24	42.667	−18.667	8.167
176	157.333	18.667	2.215
			16.526

Decision rule: $df = (c - 1) = (3 - 1) = 2$. If $\chi^2_{STAT} > 5.9915$, reject H_0.

Test statistic: $\chi^2_{STAT} = \sum_{\text{all cells}} \frac{(f_0 - f_e)}{f_e} = 16.526$.

Decision: Because $\chi^2_{STAT} = 16.526 > 5.9915$, reject H_0. There is a significant difference in the age groups with respect to major grocery shopping day. **(b)** p-value = 0.0003. The probability that the test statistic is greater than or equal to 16.526 is 0.0003, if the null hypothesis is true.

11.18 (a) Because $\chi^2_{STAT} = 6.50 > 5.9915$, reject H_0. There is evidence of a difference in the percentage who often listen to rock music among the age groups. **(b)** p-value $= 0.0388$.

11.20 $df = (r - 1)(c - 1) = (4 - 1)(5 - 1) = 12$.

11.22 $\chi^2_{STAT} = 92.1028 > 16.919$, reject H_0 and conclude that there is evidence of a relationship between the type of dessert ordered and the type of entrée ordered.

11.24 (a) H_0: There is no relationship between the commuting time of company employees and the level of stress-related problems observed on the job. H_1: There is a relationship between the commuting time of company employees and the level of stress-related problems observed on the job.

f_0	f_e	$(f_0 - f_e)$	$(f_0 - f_e)^2/f_e$
9	12.1379	−3.1379	0.8112
17	20.1034	−3.1034	0.4791
18	11.7586	6.2414	3.3129
5	5.2414	−0.2414	0.0111
8	8.6810	−0.6810	0.0534
6	5.0776	0.9224	0.1676
18	14.6207	3.3793	0.7811
28	24.2155	3.7845	0.5915
7	14.1638	−7.1638	3.6233
			9.8311

Decision rule: If $\chi^2_{STAT} > 13.277$, reject H_0.

Test statistic: $\chi^2_{STAT} = \sum_{\text{all cells}} \frac{(f_0 - f_e)^2}{f_e} = 9.8311.$

Decision: Because $\chi^2_{STAT} = 9.8311 < 13.277$, do not reject H_0. There is insufficient evidence to conclude that there is a relationship between the commuting time of company employees and the level of stress-related problems observed on the job. **(b)** Because $\chi^2_{STAT} = 9.831 > 9.488$, reject H_0. There is enough evidence at the 0.05 level to conclude that there is a relationship.

11.26 Strictly speaking, the proportion reading a book for relaxation is not significantly different across the age groups at 5% level. Results in (a) and (b) differ due to the fact that the other variables (watching TV, listening to music) differ across age groups, which is masked if these variables are combined into a single category.

11.30 (a) Because $\chi^2_{STAT} = 0.412 < 3.841$, do not reject H_0. There is insufficient evidence to conclude that there is a relationship between a student's gender and pizzeria selection. **(b)** Because $\chi^2_{STAT} = 2.624 < 3.841$, do not reject H_0. There is insufficient evidence to conclude that there is a relationship between a student's gender and pizzeria selection. **(c)** Because $\chi^2_{STAT} = 4.956 < 5.991$, do not reject H_0. There is insufficient evidence to conclude that there is a relationship between price and pizzeria selection. **(d)** p-value $= 0.0839$. The probability of a sample that gives a test statistic equal to or greater than 4.956 is 8.39% if the null hypothesis of no relationship between price and pizzeria selection is true.

11.32 (a) Because $\chi^2_{STAT} = 11.895 < 12.592$, do not reject H_0. There is not enough evidence to conclude that there is a relationship between the attitudes of employees toward the use of self-managed work teams and employee job classification. **(b)** Because $\chi^2_{STAT} = 3.294 < 12.592$, do not reject H_0. There is insufficient evidence to conclude that there is a relationship between the attitudes of employees toward vacation time without pay and employee job classification.

CHAPTER 12

12.2 (a) Yes. **(b)** Yes. **(c)** No. **(d)** Yes.

12.4 (a) The scatter plot shows a positive linear relationship. **(b)** For each increase in shelf space of an additional foot, predicted weekly sales are estimated to increase by \$7.40. **(c)** $\hat{Y} = 145 + 7.4X = 145 + 7.4(8) = 204.2$, or \$204.20.

12.6 (b) $b_0 = -2.37, b_1 = 0.0501$ **(c)** For every cubic foot increase in the amount moved, predicted labor hours are estimated to increase by 0.0501. **(d)** 22.67 labor hours.

12.8 (b) The regression equation is MPG $= 29.5 - 0.0314$ Horsepower. **(c)** If horsepower increases by 1 unit, a car's MPG performance is expected to decrease by 0.0314 units. **(c)** $\hat{Y} = 23.85$.

12.10 (b) $b_0 = 10.473, b_1 = 0.3839$. **(c)** For each increase of one million dollars of box office gross, the predicted DVD revenue is estimated to increase by \$0.3839 million. **(d)** $\hat{Y} = b_0 + b_1 X.$ $\hat{Y} = 10.473 + 0.3839(75) = \$39.2658$ million.

12.12 $SST = 76.$ $r^2 = \frac{64}{76} = 0.8421$ means 84.21% of total variation is explained by the regression.

12.14 $SSR = 36 - 12 = 24.$ $r^2 = \frac{24}{36} = 0.6667$ implies 66.67% of total variation is explained by the regression equation.

12.16 (a) $r^2 = \frac{SSR}{SST} = \frac{20{,}535}{30{,}025} = 0.684$. 68.4% of the variation in sales can be explained by the variation in shelf space.

(b) $S_{YX} = \sqrt{\frac{SSE}{n-2}} = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2}{n-2}} = \sqrt{\frac{9{,}490}{10}} = 30.8058.$

(c) Based on (a) and (b), the model should be useful for predicting sales.

12.18 (a) $r^2 = 0.8892$. 88.92% of the variation in labor hours can be explained by the variation in cubic feet moved. **(b)** $S_{YX} = 5.0314$ **(c)** Based on (a) and (b), the model should be very useful for predicting the labor hours.

12.20 (a) $r^2 = 34.6\%$. 34.6% of the total variance is explained by the linear regression. **(b)** $S = 1.46302$. **(c)** Going by 34.6% coefficient of determination, it does not seem that horsepower is a good predictor of MPG, since it explains only 34.6% of the total variation.

12.22 (a) $r^2 = 0.5452$. 54.52% of the variation in DVD revenue can be explained by the variation in box office gross. **(b)** $S_{YX} = 15.3782$. The variation of DVD revenue around the prediction line is \$15.3782 million. The typical difference between actual DVD revenue and the predicted DVD revenue using the regression equation is approximately \$15.3782 million. **(c)** Based on (a) and (b), the model is useful for predicting DVD revenue. **(d)** Other variables that might explain the variation in DVD revenue could be the amount spent on advertising, the timing of the release of the DVDs, and the type of movie.

12.24 A residual analysis of the data indicates a pattern, with sizable clusters of consecutive residuals that are either all positive or all negative. This pattern indicates a violation of the assumption of linearity. A curvilinear model should be investigated.

12.26 There does not appear to be a pattern in the residual plot. The assumptions of regression do not appear to be seriously violated.

12.28 The histogram is slightly left-skewed, thus possibly violating normality assumption. The residual versus fit plot indicates at least one outlier.

12.30 Based on the residual plot, there appears to be a nonlinear pattern in the residuals. A curvilinear model should be investigated. There is some right-skewness in the residuals, and there is some violation of the equal-variance assumption.

12.32 (a) An increasing linear relationship exists. **(b)** There is evidence of a strong positive autocorrelation among the residuals.

12.34 (a) No, because the data were not collected over time. **(b)** If a single store had been selected and studied over a period of time, you would compute the Durbin-Watson statistic.

12.36 (a)

$$b_1 = \frac{SSXY}{SSX} = \frac{201399.05}{12495626} = 0.0161$$

$$b_0 = \overline{Y} - b_1\overline{X} = 71.2621 - 0.0161\,(4{,}393) = 0.458$$

(b) $\hat{Y} = 0.458 + 0.0161X = 0.458 + 0.0161(4{,}500) = 72.908$, or \$72,908. **(c)** There is no evidence of a pattern in the residuals over time.

(d) $D = \dfrac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} = \dfrac{1{,}243.2244}{599.0683} = 2.08 > 1.45$. There is no evidence of positive autocorrelation among the residuals. **(e)** Based on a residual analysis, the model appears to be adequate.

12.38 (a) $b_0 = -2.535, b_1 = 0.06073$. **(b)** \$2,505.40. **(d)** $D = 1.64 > d_U = 1.42$, so there is no evidence of positive autocorrelation among the residuals. **(e)** The plot shows some nonlinear pattern, suggesting that a nonlinear model might be better. Otherwise, the model appears to be adequate.

12.40 (a) 1.8571. **(b)** $t\,(0.99, 13) = 2.65$. **(c)** Since $t_{STAT} < t(0.99, 13)$, the null hypothesis of no linear relationship cannot be rejected.

12.42 (a) $t_{STAT} = \dfrac{b_1 - \beta_1}{S_{b_1}} = \dfrac{7.4}{1.59} = 4.65 > 2.2281$. Reject H_0. There is evidence of a linear relationship between shelf space and sales.
(b) $b_1 \pm t_{\alpha/2}S_{b_1} = 7.4 \pm 2.2281(1.59)\ 3.86 \le \beta_1 \le 10.94$.

12.44 (a) $t_{STAT} = 16.52 > 2.0322$; reject H_0. There is evidence of a linear relationship between the number of cubic feet moved and labor hours. **(b)** $0.0439 \le \beta_1 \le 0.0562$.

12.46 (a) At 1% level of significance there is evidence of linear relationship between horsepower of a car and its MPG performance.
(b) $\text{CI} = -0.0314 \pm 2.1 * 0.0102 = (-0.0527, -0.0100)$.

12.48 (a) $t_{STAT} = 4.8964 > 2.086$ or because the p-value is virtually $0 < 0.05$; reject H_0. There is evidence of a linear relationship between box office gross and sales of DVDs. **(b)** $3.3072 \le \beta_1 \le 5.3590$.

12.50 (a) (% daily change in BGU) $= b_0 + 3.0$ (% daily change in Russell 1000 index). **(b)** If the Russell 1000 gains 10% in a year, BGU is expected to gain an estimated 30%. **(c)** If the Russell 1000 loses 20% in a year, BGU is expected to lose an estimated 60%. **(d)** Risk takers will be attracted to leveraged funds, and risk-averse investors will stay away.

12.52 (a), (b) First weekend and U.S. gross: $r = 0.2526$, $t_{STAT} = -0.5221 < 2.7764$, p-value $= 0.6292 > 0.05$. Do not reject H_0. At the 0.05 level of significance, there is a insufficient evidence of a linear relationship between First weekend sales and U.S. gross. First weekend and worldwide gross: $r = 0.4149$, $t_{STAT} = -0.912 < 2.7764$, p-value $= 0.4134 > 0.05$. Do not reject H_0. At the 0.05 level of significance, there is a insufficient evidence of a linear relationship between first weekend sales and worldwide gross. U.S. gross and worldwide gross: $r = 0.9414$, $t_{STAT} = 5.5807 > 2.7764$, p-value $= 0.0051 < 0.05$. Reject H_0. At the 0.05 level of significance, there is evidence of a linear relationship between U.S. gross and worldwide gross.

12.54 (a) $r = 0.5497$. There appears to be a moderate positive linear relationship between the average Wonderlic score of football players trying out for the NFL and the graduation rate for football players at selected schools. **(b)** $t_{STAT} = 3.9485$, p-value $= 0.0004 < 0.05$. Reject H_0. At the 0.05 level of significance, there is a significant linear relationship between the average Wonderlic score of football players trying out for the NFL and the graduation rate for football players at selected schools. **(c)** There is a significant linear relationship between the average Wonderlic score of football players trying out for the NFL and the graduation rate for football players at selected schools, but the positive linear relationship is only moderate.

12.56 (a) (9.99, 16.01). **(b)** (8.778, 17.221).

12.58 (a) $\hat{Y} = 145 + 7.4(8) = 204.2$ $\hat{Y} \pm t_{\alpha/2}S_{YX}\sqrt{h_i}$

$$= 204.2 \pm 2.2281(30.81)\sqrt{0.1373}$$

$$178.76 \le \mu_{Y|X=8} \le 229.64.$$

(b) $\hat{Y} \pm t_{\alpha/2}S_{YX}\sqrt{1 + h_i}$

$$= 204.2 \pm 2.2281(30.81)\sqrt{1 + 0.1373}$$

$$131.00 \le Y_{X=8} \le 277.40.$$

(c) Part (b) provides a prediction interval for the individual response given a specific value of the independent variable, and part (a) provides an interval estimate for the mean value, given a specific value of the independent variable. Because there is much more variation in predicting an individual value than in estimating a mean value, a prediction interval is wider than a confidence interval estimate.

12.60

New Obs	Fit	SE Fit	95% CI	95% PI
1	23.819	0.348	(23.087, 24.550)	(20.659, 26.978)

Values of Predictors for New Observations

New Obs	Horsepower
1	180

12.62 (a) $217.4561 \le \mu_{Y|X=150} \le 281.441$. **(b)** $124.4653 \le Y_{X=150} \le 374.4318$. **(c)** Part (b) provides a prediction interval for an individual response given a specific value of X, and part (a) provides a confidence interval estimate for the mean value, given a specific value of X. Because there is much more variation in predicting an individual value than in estimating a mean, the prediction interval is wider than the confidence interval.

12.74 (a) $b_0 = 24.84, b_1 = 0.14$. **(b)** For each additional case, the predicted delivery time is estimated to increase by 0.14 minutes.
(c) 45.84. **(d)** No, 500 is outside the relevant range of the data used to fit the regression equation. **(e)** $r^2 = 0.972$. **(f)** There is no obvious pattern in the residuals, so the assumptions of regression are met. The model appears to be adequate. **(g)** $t_{STAT} = 24.88 > 2.1009$; reject H_0.
(h) $44.88 \le \mu_{Y|X=150} \le 46.80$. $41.56 \le Y_{X=150} \le 50.12$.

12.76 (a) $b_0 = -122.3439, b_1 = 1.7817$. **(b)** For each additional thousand dollars in assessed value, the estimated selling price of a house increases by \$1.7817 thousand. The estimated selling price of a house with a 0 assessed value is $\$-122.3439$ thousand. However, this interpretation is not meaningful because the assessed value cannot be below 0. **(c)** $\hat{Y} = -122.3439 + 1.78171X = -122.3439 + 1.78171(170) = 180.5475$ thousand dollars. **(d)** $r^2 = 0.9256$. So 92.56%

of the variation in selling price can be explained by the variation in assessed value. **(e)** Neither the residual plot nor the normal probability plot reveals any potential violation of the linearity, equal variance, and normality assumptions. **(f)** $t_{STAT} = 18.6648 > 2.0484$, p-value is virtually 0. Because p-value < 0.05, reject H_0. There is evidence of a linear relationship between selling price and assessed value. **(g)** $1.5862 \le \beta_1 \le 1.9773$.

12.78 (a) $b_0 = 0.30, b_1 = 0.00487$. **(b)** For each additional point on the GMAT score, the predicted GPA is estimated to increase by 0.00487. Because a GMAT score of 0 is not possible, the Y intercept does not have a practical interpretation. **(c)** 3.222. **(d)** $r^2 = 0.798$. **(e)** There is no obvious pattern in the residuals, so the assumptions of regression are met. The model appears to be adequate. **(f)** $t_{STAT} = 8.43 > 2.1009$; reject H_0. **(g)** $3.144 \le \mu_{Y|X=600} \le 3.301$, $2.866 \le Y_{X=600} \le 3.559$. **(h)** $.00366 \le \beta_1 \le .00608$.

12.80 (a) There is no clear relationship shown on the scatter plot. **(c)** Looking at all 23 flights, when the temperature is lower, there is likely to be some O-ring damage, particularly if the temperature is below 60 degrees. **(d)** 31 degrees is outside the relevant range, so a prediction should not be made. **(e)** Predicted $Y = 18.036 - 0.240X$, where $X =$ temperature and $Y =$ O-ring damage **(g)** A nonlinear model would be more appropriate. **(h)** The appearance on the residual plot of a nonlinear pattern indicates that a nonlinear model would be better. It also appears that the normality assumption is invalid.

12.82 (a) $b_0 = -6.2448, b_1 = 2.9576$. **(b)** For each additional million-dollar increase in revenue, the franchise value will increase by an estimated \$2.9576 million. Literal interpretation of b_0 is not meaningful because an operating franchise cannot have zero revenue. **(c)** \$437.3901 million. **(d)** $r^2 = 0.981$. 98.1% of the variation in the value of an NBA franchise can be explained by the variation in its annual revenue. **(e)** There does not appear to be a pattern in the residual plot. The assumptions of regression do not appear to be seriously violated. **(f)** $t_{STAT} = 38.0207 > 2.0484$ or because the p-value is approximately 0, reject H_0 at the 5% level of significance. There is evidence of a linear relationship between annual revenue and franchise value. **(g)** $431.0467 \le \mu_{Y|X=150} \le 443.7334$. **(h)** $408.8257 \le Y_{X=150} \le 465.9544$. **(i)** The strength of the relationship between revenue and value is stronger for baseball and NBA franchises than for European soccer teams.

12.84 (a) $b_0 = -2{,}629.222, b_1 = 82.472$. **(b)** For each additional centimeter in circumference, the weight is estimated to increase by 82.472 grams. **(c)** 2,319.08 grams. **(d)** Yes, since circumference is a very strong predictor of weight. **(e)** $r^2 = 0.937$. **(f)** There appears to be a nonlinear relationship between circumference and weight. **(g)** p-value is virtually $0 < 0.05$; reject H_0. **(h)** $72.7875 \le \beta_1 \le 92.156$.

12.86 (b) Thickness = 71.9 − 0.0101 Pressure **(c)** If pressure = 0, Thickness = 71.9, which is the Y-intercept. For every unit increase in pressure, Thickness is expected to decrease by 0.0.0101 units. **(d)** R-Sq = 0.2% => 0.2% of total variation is being explained by the linear regression. **(f)** P-value = 0.779 => there does not seem to be any evidence of linear relationship between pH and Thickness. **(g)** 95% CI: −0.01 ± 2.01*0.0357 = (−0.081, 0.062)

12.88 (b) Thickness = −28.2 + 0.417 Voltage **(c)** If Voltage = 0, Thickness = −28.2, which is the Y-intercept. In this case this value will have no physical interpretation. For every unit increase in Voltage, Thickness is expected to increase by 0.417 units. **(d)** R-Sq = 67.3% => 67.3% of total variation is being explained by the linear regression. **(f)** P-value = 0.00 => there seems to be strong evidence of linear relationship between Voltage and Thickness. **(g)** 95% CI: 0.417 ± 2.01*0.0420 = (0.3326, 0.5014)

12.90 (a) The correlation between compensation and stock performance is −0.0389. **(b)** $t_{STAT} = -0.4912 > -1.96$; p-value $= 0.6239 > 0.05$. The correlation between compensation and stock performance is not significant. **(c)** The lack of correlation between compensation and stock performance was surprising (or maybe it shouldn't have been!).

CHAPTER 13

13.2 (a) Expected decrease in Y value is 7 per unit increase in X_1, when X_2 is held at a constant level. Expected increase in Y value is 26.2 per unit increase in X_2, when X_1 is held at a constant level. **(b)** When both X_1 and X_2 are at 0, expected value of Y is 90.

13.4 (a) $\hat{Y} = -2.72825 + 0.047114X_1 + 0.011947X_2$. **(b)** For a given number of orders, for each increase of \$1,000 in sales, the distribution cost is estimated to increase by \$47.114. For a given amount of sales, for each increase of one order, the distribution cost is estimated to increase by \$11.95. **(c)** The interpretation of b_0 has no practical meaning here because it would represent the estimated distribution cost when there were no sales and no orders. **(d)** $\hat{Y} = -2.72825 + 0.047114(400) + 0.011947(4500) = 69.878$, or \$69,878. **(e)** $\$66{,}419.93 \le \mu_{Y|X} \le \$73{,}337.01$. **(f)** $\$59{,}380.61 \le Y_X \le \$80{,}376.33$. **(g)** The interval in (e) is narrower because it is estimating the mean value, not an individual value.

13.6 (a) $\hat{Y} = 156.4 + 13.081X_1 + 16.795X_2$. **(b)** For a given amount of newspaper advertising, each increase by \$1,000 in radio advertising is estimated to result in an increase in sales of \$13,081. For a given amount of radio advertising, each increase by \$1,000 in newspaper advertising is estimated to result in an increase in sales of \$16,795. **(c)** When there is no money spent on radio advertising and newspaper advertising, the estimated mean sales is \$156,430.44. **(d)** Holding the other independent variable constant, newspaper advertising seems to be more effective because its slope is greater.

13.8 (a) $\hat{Y} = 400.8057 + 456.4485X_1 - 2.4708X_2$ where $X_1 =$ land area, $X_2 =$ age. **(b)** For a given age, each increase by one acre in land area is estimated to result in an increase in appraised value by \$456.45 thousands. For a given land area, each increase of one year in age is estimated to result in a decrease in appraised value by \$2.47 thousands. **(c)** The interpretation of b_0 has no practical meaning here because it would represent the estimated appraised value of a new house that has no land area. **(d)** $\hat{Y} = 400.8057 + 456.4485(0.25) - 2.4708(45) =$ \$403.73 thousands. **(e)** $372.7370 \le \mu_{Y|X} \le 434.7243$. **(f)** $235.1964 \le Y_X \le 572.2649$.

13.10 (a) $r^2 = \dfrac{SSR}{SST} = \dfrac{517337}{531855} = 0.9727.97.27\%$ of the total variability in the fast food burgers is explained by the fat and carbohydrate content of the burgers. **(b)** Adjusted $r^2 = 1 - \dfrac{MSE}{MST} = 96.9\%$.

13.12 (a) $MSR = 258669, MSE = 854, F_{STAT} = 302.89$. **(b)** p-value is 0.00. The relationship is therefore significant at 1% level.

13.14 (a) $F_{STAT} = 74.13 > 3.467$; reject H_0. **(b)** p-value $= 0$. **(c)** $r^2 = 0.8759$. 87.59% of the variation in distribution cost can be explained by variation in sales and variation in number of orders. **(d)** $r^2_{adj} = 0.8641$.

13.16 (a) $F_{STAT} = 40.16 > 3.522$. Reject H_0. There is evidence of a significant linear relationship. **(b)** p-value < 0.001. **(c)** $r^2 = 0.8087$. 80.87% of the variation in sales can be explained by variation in radio advertising and variation in newspaper advertising. **(d)** $r^2_{adj} = 0.7886$.

13.18 (a)–(e) Based on a residual analysis, there is no evidence of a violation of the assumptions of regression. **(f)** $D = 2.26$ **(g)** $D = 2.26 > 1.55$. There is no evidence of positive autocorrelation in the residuals.

13.20 (a) There appears to be a quadratic relationship in the plot of the residuals against both radio and newspaper advertising. (b) Since the data are not collected over time, the Durbin-Watson test is not appropriate. **(c)** Curvilinear terms for both of these explanatory variables should be considered for inclusion in the model.

13.22 (a) The residual analysis reveals no patterns. (b) Since the data are not collected over time, the Durbin-Watson test is not appropriate. **(c)** There are no apparent violations in the assumptions.

13.24 (a) $b_1/S_{b1} = 9/2.9 = 3.10$ and $b_2/S_{b2} = 12/4.7 = 2.55$. X_1 has the larger slope. **(b)** $9 \pm 2.07 * 2.9 = (2.997, 15.00)$. **(c)** Both X_1 and X_2 are significant at 5% level. Both may be included in the model.

13.26 (a) 95% confidence interval on β_1: $b_1 \pm tS_{b_1}$, 0.0471 ± 2.0796 (0.0203), $0.0049 \le \beta_1 \le 0.0893$. **(b)** For X_1: $t_{STAT} = b_1/S_{b_1} = 0.0471/0.0203 = 2.32 > 2.0796$. Reject H_0. There is evidence that X_1 contributes to a model already containing X_2. For X_2: $t_{STAT} = b_1/S_{b_1} = 0.0112/0.0023 = 5.31 > 2.0796$. Reject H_0. There is evidence that X_2 contributes to a model already containing X_1. Both X_1 (sales) and X_2 (orders) should be included in the model.

13.28 (a) $9.398 \le \beta_1 \le 16.763$. **(b)** For X_1: $t_{STAT} = 7.43 > 2.093$. Reject H_0. There is evidence that X_1 contributes to a model already containing X_2. For X_2: $t_{STAT} = 5.67 > 2.093$. Reject H_0. There is evidence that X_2 contributes to a model already containing X_1. Both X_1 (radio advertising) and X_2 (newspaper advertising) should be included in the model.

13.30 (a) $227.5865 \le \beta_1 \le 685.3104$. **(b)** For X_1: $t_{STAT} = 4.0922$ and p-value $= 0.0003$. Because p-value < 0.05, reject H_0. There is evidence that X_1 contributes to a model already containing X_2. For X_2: $t_{STAT} = -3.6295$ and p-value $= 0.0012$. Because p-value < 0.05 reject H_0. There is evidence that X_2 contributes to a model already containing X_1. Both X_1 (land area) and X_2 (age) should be included in the model.

13.32 $t_{STAT} = 2.73$. $t(0.975,12) = 2.18$. Variable X_2 makes a significant contribution to the model.

13.34 (a) $\hat{Y} = 243.7371 + 9.2189X_1 + 12.6967X_2$, where $X_1 =$ number of rooms and $X_2 =$ neighborhood (east $= 0$) **(b)** Holding constant the effect of neighborhood, for each additional room, the selling price is estimated to increase by 9.2189 thousands of dollars, or $9,218.9. For a given number of rooms, a west neighborhood is estimated to increase the selling price over an east neighborhood by 12.6967 thousands of dollars, or $12,696.7. **(c)** $\hat{Y} = 243.7371 + 9.2189(9) + 12.6967(0) = 326.7076$, or $326, 707.6. $\$309{,}560.04 \le Y_X \le \$343{,}855.1$. $\$321{,}471.44 \le \mu_{Y|X} \le \$331{,}943.71$. **(d)** Based on a residual analysis, the model appears to be adequate. **(e)** $F_{STAT} = 55.39$, the p-value is virtually 0. Because p-value < 0.05, reject H_0. There is evidence of a significant relationship between selling price and the two independent variables (rooms and neighborhood). **(f)** For X_1:$t_{STAT} = 8.9537$, the p-value is virtually 0. Reject H_0. Number of rooms makes a significant contribution and should be included in the model. For X_2:$t_{STAT} = 3.5913$, p-value $= 0.0023 < 0.05$, Reject H_0. Neighborhood makes a significant contribution and should be included in the model. Based on these results, the regression model with the two independent variables should be used. **(g)** $7.0466 \le \beta_1 \le 11.3913$. **(h)** $5.2378 \le \beta_2 \le 20.1557$. **(i)** $r^2_{adj} = 0.851$. **(j)** The slope of selling price with number of rooms is the same, regardless of whether the house is located in an east or west neighborhood. **(k)** $\hat{Y} = 253.95 + 8.032X_1 - 5.90X_2 + 2.089X_1X_2$. For $X_1 X_2$, p-value $= 0.330$. Do not reject H_0. There is no evidence that the interaction term makes a contribution to the model. **(l)** The model in (b) should be used.

13.36 (a) Predicted time $= 8.01 + 0.00523$ Depth $- 2.105$ Dry. **(b)** Holding constant the effect of type of drilling, for each foot increase in depth of the hole, the drilling time is estimated to increase by 0.00523 minutes. For a given depth, a dry drilling hole is estimated to reduce the drilling time over wet drilling by 2.1052 minutes. **(c)** 6.428 minutes, $6.210 \le \mu_{Y|X} \le 6.646$, $4.923 \le Y_X \le 7.932$. **(d)** The model appears to be adequate. **(e)** $F_{STAT} = 111.11 > 3.09$; reject H_0. **(f)** $t_{STAT} = 5.03 > 1.9847$; reject H_0. $t_{STAT} = -14.03 < -1.9847$; reject H_0. Include both variables. **(g)** $0.0032 \le \beta_1 \le 0.0073$. **(h)** $-2.403 \le \beta_2 \le -1.808$. **(i)** 69.0%. **(j)** The slope of the additional drilling time with the depth of the hole is the same, regardless of the type of drilling method used. **(k)** The p-value of the interaction term $= 0.462 > 0.05$, so the term is not significant and should not be included in the model. **(l)** The model in part (b) should be used.

13.38 The regression equation is

Calories = −10.9 + 10.4 Fat + 6.40 Carbs − 0.0191 Interaction

Predictor	Coef	SE	Coef	T	P
Constant	−10.91	96.52	−0.11	0.911	
Fat	10.388	3.286	3.16	0.006	
Carbs	6.399	1.717	3.73	0.002	
Interaction	−0.01915	0.05258	−0.36	0.721	

The interaction term is not significant. No interaction model may be used.

13.40 (a) The p-value of the interaction term $= 0.002 < 0.05$, so the term is significant and should be included in the model. **(b)** Use the model developed in this problem.

13.42 (a) For $X_1 X_2$, p-value $= 0.2353 > 0.05$. Do not reject H_0. There is insufficient evidence that the interaction term makes a contribution to the model. **(b)** Because there is not enough evidence of an interaction effect between total staff present and remote hours, the model in Problem 13.7 should be used.

13.50 (a) $\hat{Y} = -3.9152 + 0.0319X_1 + 4.2228X_2$, where $X_1 =$ number cubic feet moved and $X_2 =$ number of pieces of large furniture. **(b)** Holding constant the number of pieces of large furniture, for each additional cubic foot moved, the labor hours are estimated to increase by 0.0319. Holding constant the amount of cubic feet moved, for each additional piece of large furniture, the labor hours are estimated to increase by 4.2228. **(c)** $\hat{Y} = -3.9152 + 0.0319(500) + 4.2228(2) = 20.4926$. **(d)** Based on a residual analysis, the errors appear to be normally distributed. The equal-variance assumption might be violated because the variances appear to be larger around the center region of both independent variables. There might also be violation of the linearity assumption. A model with quadratic terms for both independent variables might be fitted. **(e)** $F_{STAT} = 228.80$, p-value is virtually 0. Because p-value < 0.05, reject H_0. There is evidence of a significant relationship between labor hours and the two independent variables (the amount of cubic feet moved and the number of pieces of large furniture). **(f)** The p-value is virtually 0. The probability of obtaining a test statistic of 228.80 or greater is virtually 0 if there is no significant relationship between labor hours and the two independent variables (the amount of cubic feet moved and the number of pieces of large furniture). **(g)** $r^2 = 0.9327.93.27\%$ of the variation in labor hours can be explained by variation in the number of cubic feet moved and the number of pieces of large furniture. **(h)** $r^2_{adj} = 0.9287$. **(i)** For X_1: $t_{STAT} = 6.9339$, the p-value is virtually 0. Reject H_0. The number of cubic feet moved makes a significant contribution and should be included in the model. For X_2: $t_{STAT} = 4.6192$, the p-value is virtually 0. Reject H_0. The number of pieces of large furniture makes a significant contribution and should be included in the model. Based on these results, the regression model with the two independent variables should be used. **(j)** For X_1: $t_{STAT} = 6.9339$, the p-value is virtually 0. The probability of obtaining a sample that will yield a test statistic farther away than 6.9339 is virtually 0 if the number of cubic feet moved does not make a significant contribution, holding the effect of the number of pieces of large furniture constant. For X_2: $t_{STAT} = 4.6192$, the p-value is virtually 0. The probability of obtaining a sample that will yield a test statistic farther away than 4.6192 is virtually 0 if the number of pieces of large furniture does not make a significant contribution, holding the effect of the amount of cubic feet moved constant. **(k)** $0.0226 \leq \beta_1 \leq 0.0413$. You are 95% confident that the mean labor hours will increase by between 0.0226 and 0.0413 for each additional cubic foot moved, holding constant the number of pieces of large furniture. In Problem 12.44, you are 95% confident that the labor hours will increase by between 0.0439 and 0.0562 for each additional cubic foot moved, regardless of the number of pieces of large furniture.

13.52 **(a)** $\hat{Y} = -120.0483 + 1.7506X_1 + 0.3680X_2$, where X_1 = assessed value and X_2 = time since assessment. **(b)** Holding constant the time period, for each additional thousand dollars of assessed value, the selling price is estimated to increase by 1.7506 thousand dollars. Holding constant the assessed value, for each additional month since assessment, the selling price is estimated to increase by 0.3680 thousand dollars. **(c)** $\hat{Y} = -120.0483 + 1.7506(170) + 0.3680(12) = 181.9692$ thousand dollars. **(d)** Based on a residual analysis, the model appears to be adequate. **(e)** $F_{STAT} = 223.46$, the p-value is virtually 0. Because p-value < 0.05, reject H_0. There is evidence of a significant relationship between selling price and the two independent variables (assessed value and time since assessment). **(f)** The p-value is virtually 0. The probability of obtaining a test statistic of 223.46 or greater is virtually 0 if there is no significant relationship between selling price and the two independent variables (assessed value and time since assessment). **(g)** $r^2 = 0.9430$. 94.30% of the variation in selling price can be explained by variation in assessed value and time since assessment. **(h)** $r^2_{adj} = 0.9388$. **(i)** For X_1: $t_{STAT} = 20.4137$, the p-value is virtually 0. Reject H_0. The assessed value makes a significant contribution and should be included in the model. For X_2: $t_{STAT} = 2.8734$, p-value $= 0.0078 < 0.05$. Reject H_0. The time since assessment makes a significant contribution and should be included in the model. Based on these results, the regression model with the two independent variables should be used. **(j)** For X_1: $t_{STAT} = 20.4137$, the p-value is virtually 0. The probability of obtaining a sample that will yield a test statistic farther away than 20.4137 is virtually 0 if the assessed value does not make a significant contribution, holding time since assessment constant. For X_2: $t_{STAT} = 2.8734$, the p-value is virtually 0. The probability of obtaining a sample that will yield a test statistic farther away than 2.8734 is virtually 0 if the time since assessment does not make a significant contribution holding the effect of the assessed value constant. **(k)** $1.5746 \leq \beta_1 \leq 1.9266$. You are 95% confident that the selling price will increase by an amount somewhere between \$1.5746 thousand and \$1.9266 thousand for each additional thousand-dollar increase in assessed value, holding constant the time since assessment. In Problem 12.76, you are 95% confident that the selling price will increase by an amount somewhere between \$1.5862 thousand and \$1.9773 thousand for each additional thousand-dollar increase in assessed value, regardless of the time since assessment.

13.54 **(a)** $\hat{Y} = 163.7751 + 10.7252X_1 - 0.2843X_2$, where X_1 = size and X_2 = age. **(b)** Holding age constant, for each additional thousand square feet, the assessed value is estimated to increase by \$10.7252 thousand. Holding size constant, for each additional year, the assessed value is estimated to decrease by \$0.2843 thousand. **(c)** $\hat{Y} = 163.7751 + 10.7252(1.75) - 0.2843(10) = 179.7017$ thousand dollars. **(d)** Based on a residual analysis, the errors appear to be normally distributed. The equal-variance assumption appears to be valid. There might be a violation of the linearity assumption for age. You might want to include a quadratic term in the model for age. **(e)** $F_{STAT} = 28.58$, p-value $= 0.0000272776$. Because p-value $= 0.0000 < 0.05$, reject H_0. There is evidence of a significant relationship between assessed value and the two independent variables (size and age). **(f)** p-value $= 0.0000272776$. The probability of obtaining an F_{STAT} test statistic of 28.58 or greater is virtually 0 if there is no significant relationship between assessed value and the two independent variables (size and age). **(g)** $r^2 = 0.8265$. 82.65% of the variation in assessed value can be explained by variation in size and age. **(h)** $r^2_{adj} = 0.7976$. **(i)** For X_1: $t_{STAT} = 3.5581$, p-value $= 0.0039 < 0.05$. Reject H_0. The size of a house makes a significant contribution and should be included in the model. For X_2: $t_{STAT} = -3.4002$, p-value $= 0.0053 < 0.05$. Reject H_0. The age of a house makes a significant contribution and should be included in the model. Based on these results, the regression model with the two independent variables should be used. **(j)** For X_1: p-value $= 0.0039$. The probability of obtaining a sample that will yield a test statistic farther away than 3.5581 is 0.0039 if the size of a house does not make a significant contribution, holding age constant. For X_2: p-value $= 0.0053$. The probability of obtaining a sample that will yield a test statistic farther away than -3.4002 is 0.0053 if the age of a house does not make a significant contribution, holding the effect of the size constant. **(k)** $4.1572 \leq \beta_1 \leq 17.2928$. You are 95% confident that the mean assessed value will increase by an amount somewhere between \$4.1575 thousand and \$17.2928 thousand for each additional thousand-square-foot increase in the size of a house, holding constant the age. In Problem 12.77, you are 95% confident that the mean assessed value will increase by an amount somewhere between \$9.4695 thousand and \$23.7972 thousand for each additional thousand-square-foot increase in heating area, regardless of the age. **(I)** Based on your answers to (b) through (k), the age of a house does have an effect on its assessed value.

13.56 **(a)** $\hat{Y} = 157.8976 - 18.4490X_1 - 3.2787X_2$, where X_1 = ERA and X_2 = league (American = 0, National = 1) **(b)** Holding constant the effect of the league, for each additional ERA, the number of wins is estimated to decrease by 18.4490. For a given ERA, a team in the National League is estimated to have 3.2787 fewer wins than a team in the American League. **(c)** 74.8771 wins Confidence interval: 69.6315 to 80.1227 Prediction interval: 57.3027 to 92.4515. **(d)** There is no apparent violation of the assumptions. **(e)** $F_{STAT} = 12.7768 > 3.35$, *p-value* $= 0.0001$. Because p-value < 0.05, reject H_0. There is evidence of a significant relationship between wins and the two independent variables (ERA and league). **(f)** For X_1: $t_{STAT} = -5.0424 < -2.0518$, the p-value is virtually 0. Reject H_0. ERA makes a significant contribution and should be included in the model. For X_2: $t_{STAT} = -1.0844 > -2.0518$, p-value $= 0.0502 > 0.05$. Do not reject H_0. The league does not make a significant contribution and should not be included in the model. Based on these results, the regression model with only the ERA as the independent variable should be used. **(g)** $-25.9562 \leq \beta_1 \leq -10.9418$. **(h)** $-9.4825 \leq \beta_2 \leq 2.9250$. **(i)** $r^2 = 0.4862$. 48.62% of the variation in wins can be explained by the variation in ERA and league. **(j)** The slope of the number of wins with ERA is the same, regardless of whether the team belongs to the American League or the National League. **(k)** For X_1X_2: $t_{STAT} = -0.2802 > -2.0555$ the p-value is $0.7815 > 0.05$. Do not reject H_0. There is no evidence that the interaction term makes a contribution to the model. **(m)** The model with one independent variable (ERA) should be used.

13.58 The r^2 of the multiple regression is very low, at 0.0645. Only 6.45% of the variation in thickness can be explained by the variation of pressure and temperature. The F test statistic for the combined significant of pressure and temperature is 1.621, with p-value $= 0.2085$. Hence, at a 5% level of significance, there is not enough evidence to conclude that both pressure and temperature affect thickness. The p-value of the t test for the significance of pressure is $0.8307 > 0.05$. Hence, there is insufficient evidence to conclude that pressure affects thickness, holding constant the effect of temperature. The p-value of the t test for the significance of temperature is 0.0820, which is also > 0.05. There is insufficient evidence to conclude that temperature affects thickness at the 5% level of significance, holding constant the effect of pressure. Hence, neither pressure nor temperature affects thickness individually.

The normal probability plot does not suggest any potential violation of the normality assumption. The residual plots do not indicate potential violation of the equal variance assumption. The temperature residual plot, however, suggests that there might be a nonlinear relationship between temperature and thickness.

The r^2 of the multiple regression model is very low, at 0.0734. Only 7.34% of the variation in thickness can be explained by the variation of pressure, temperature, and the interaction of the two. The F test statistic for the model that includes pressure and temperature is 1.214, with a p-value of 0.3153. Hence, at a 5% level of significance, there is insufficient evidence to conclude that pressure, temperature, and the interaction of the two affect thickness. The p-value of the t test for the significance of pressure, temperature, and the interaction term are 0.5074, 0.4053, and 0.5111, respectively, which are all greater than 5%. Hence, there is insufficient evidence to conclude that pressure, temperature, or the interaction individually affects thickness, holding constant the effect of the other variables.

The pattern in the normal probability plot and residual plots is similar to that in the regression without the interaction term. Hence the article's suggestion that there is a significant interaction between the pressure and the temperature in the tank cannot be validated.

CHAPTER 14

14.2 (a) Day 3, Day 6. **(b)** LCL $= 0.0143$, UCL $= 0.3387$. **(c)** No, there are no special causes of variation.

14.4 (a) $n = 500, \bar{p} = 761/16{,}000 = 0.0476$.

$$\text{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$= 0.0476 + 3\sqrt{\frac{0.0476(1-0.0476)}{500}} = 0.0761$$

$$\text{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$= 0.0476 - 3\sqrt{\frac{0.0476(1-0.0476)}{500}} = 0.0190$$

(b) Because the individual points are distributed around $\bar{p}$ without any pattern and all the points are within the control limits, the process is in a state of statistical control.

14.6 (a) UCL $= 0.0176$, LCL $= 0.0082$. The proportion of unacceptable cans is below the LCL on Day 4. There is evidence of a pattern over time because the last eight points are all above the mean, and most of the earlier points are below the mean. Therefore, this process is out of control.

14.8 (a) UCL $= 0.1431$, LCL $= 0.0752$. Days 9, 26, and 30 are above the UCL. Therefore, this process is out of control.

14.12 (a) $d_2 = 2.704$. **(b)** $d_3 = 0.833$. **(c)** $D_3 = 0.076$. **(d)** $D_4 = 1.924$. **(e)** $A_2 = 0.419$.

14.14 (a) $\bar{R} = \dfrac{\sum_{i=1}^{k} R_i}{k} = 3.275$, $\bar{\bar{X}} = \dfrac{\sum_{i=1}^{k} \bar{X}_i}{k} = 5.941$. R chart: $UCL = D_4\bar{R} = 2.282(3.275) = 7.4736$. LCL does not exist. $\bar{X}$ chart: $UCL = \bar{\bar{X}} + A_2\bar{R} = 5.9413 + 0.729(3.275) = 8.3287$. $LCL = \bar{\bar{X}} - A_2\bar{R} = 5.9413 - 0.729(3.275) = 3.5538$. **(b)** The process appears to be in control because there are no points outside the control limits, there is no evidence of a pattern in the range chart, there are no points outside the control limits, and there is no evidence of a pattern in the $\bar{X}$ chart.

14.16 (a) $\bar{R} = 0.8794$, LCL does not exist, UCL $= 2.0068$. **(b)** $\bar{\bar{X}} = 20.1065$, LCL $= 19.4654$, UCL $= 20.7475$. **(c)** The process is in control.

14.18 (a) $\bar{R} = 8.145$, LCL does not exist, UCL $= 18.5869$; $\bar{\bar{X}} = 18.12$, UCL $= 24.0577$, LCL $= 12.1823$. **(b)** There are no sample ranges outside the control limits, and there does not appear to be a pattern in the range chart. The mean is above the UCL on Day 15 and below the LCL on Day 16. Therefore, the process is not in control.

14.20 (a) $\bar{R} = 0.3022$, LCL does not exist, UCL $= 0.6389$; $\bar{\bar{X}} = 90.1312$, UCL $= 90.3060$, LCL $= 89.9573$. **(b)** On Days 5 and 6, the sample ranges were above the UCL. The mean chart may be erroneous because the range is out of control. The process is out of control.

14.28 (a) The main reason that service quality is lower than product quality is because the former involves human interaction, which is prone to variation. Also, the most critical aspects of a service are often timeliness and professionalism, and customers can always perceive that the service could be done more quickly and with greater professionalism. For products, customers often cannot perceive a better or more ideal product than the one they are getting. For example, a new laptop is better and contains more interesting features than any laptop the owner has ever imagined. **(b)** Both services and products are the results of processes. However, measuring services is often harder because of the dynamic variation due to the human interaction between the service provider and the customer. Product quality is often a straightforward measurement of a static physical characteristic such as the amount of sugar in a can of soda. Categorical data are also more common in service quality. **(c)** Yes. **(d)** Yes.

14.30 (a) $\bar{p} = 0.2702$, LCL $= 0.1700$, UCL $= 0.3703$. **(b)** Yes, RudyBird's market share is in control before the in-store promotion. **(c)** All seven days of the in-store promotion are above the UCL. The promotion increased market share.

14.32 (a) $\bar{p} = 0.75175$, LCL $= 0.62215$, UCL $= 0.88135$. Although none of the points are outside the control limits, there is a clear pattern over time, with the last 13 points above the center line. Therefore, this process is not in control. **(b)** Because the increasing trend begins around Day 20, this change in method would be the assignable cause. **(c)** The control chart would have been developed using the first 20 days, and then a different control chart would be used for the final 20 points because they represent a different process.

14.34 (a) $\bar{p} = 0.1198$, LCL $= 0.0205$, UCL $= 0.2191$. **(b)** Day 24 is below the LCL; therefore, the process is out of control. **(c)** Special causes of variation should be investigated to improve the process. Next, the process should be improved to decrease the proportion of undesirable trades.

14.36 Separate p charts should be developed for each food for each shift:

Kidney—Shift 1: $\bar{p} = 0.01395$, UCL $= 0.02678$, LCL $= 0.00112$. Although there are no points outside the control limits, there is a strong increasing trend in nonconformances over time.

Kidney—Shift 2: $\bar{p} = 0.01829$, UCL $= 0.03329$, LCL $= 0.00329$. Although there are no points outside the control limits, there is a strong increasing trend in nonconformances over time.

Shrimp—Shift 1: $\bar{p} = 0.006995$, UCL $= 0.01569$, LCL $= 0$. There are no points outside the control limits, and there is no pattern over time.

Shrimp—Shift 2: $\bar{p} = 0.01023$, UCL $= 0.021$, LCL $= 0$. There are no points outside the control limits, and there is no pattern over time.

The team needs to determine the reasons for the increase in nonconformances for the kidney product. The production volume for kidney is clearly decreasing for both shifts. This can be observed from a plot of the production volume over time. The team needs to investigate the reasons for this.