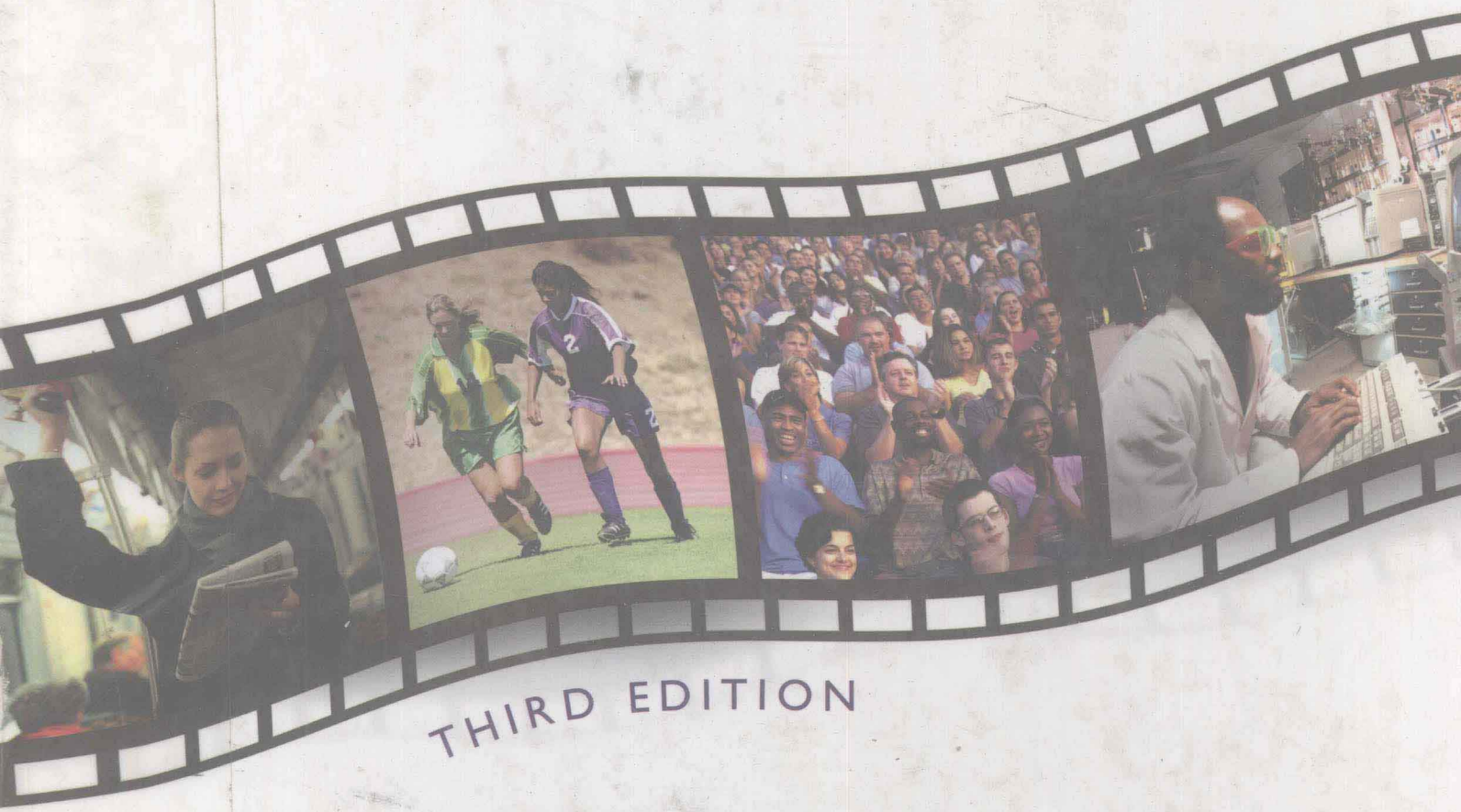
Elementary Statistics

Picturing the World



THIRD EDITION

Larson : Farber

Elementary Statistics

Picturing the World

Third Edition

Ron Larson

The Pennsylvania State University
The Behrend College

Bucks County
Community College

Upper Saddle River, NJ 07458

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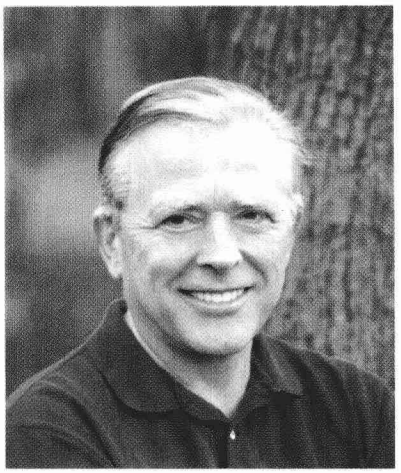

Ron Larson

The Pennsylvania State University
The Behrend College

Ron Larson received his Ph.D. in mathematics from the University of Colorado in 1970. At that time he accepted a position with Penn State University, and he currently holds the rank of professor of mathematics at the university. Larson is the lead author of more than two dozen mathematics textbooks that range from sixth grade through calculus levels. Many of his texts, such as the seventh edition of his calculus text, are leaders in their markets. Larson is also one of the pioneers in the use of multimedia and the Internet to enhance the learning of mathematics. He has authored multimedia programs, extending from the elementary school through calculus levels. Larson is a member of several professional groups and is a frequent speaker at national and regional mathematics meetings.

Betsy Farber

Bucks County
Community College

Betsy Farber received her Bachelor's degree in mathematics from Penn State University and Master's degree in mathematics from the College of New Jersey. Since 1976, she has been teaching all levels of mathematics at Bucks County Community College in Newtown, Pennsylvania, where she currently holds the rank of professor. She is particularly interested in developing new ways to make statistics relevant and interesting to her students and has been teaching statistics in many different modes—with TI-83, with MINITAB, and by distance learning as well as in the traditional classroom. A member of the American Mathematical Association of Two-Year Colleges (AMATYC), she is an author of *The Student Edition to MINITAB* and *A Guide to MINITAB.* She served as consulting editor for *Statistics, A First Course* and has written computer tutorials for the CD-ROM correlating to the texts in the Streeter Series in mathematics.

Preface

Welcome to *Elementary Statistics: Picturing the World*, Third Edition. We are grateful for the overwhelming acceptance and support of the First and Second Editions. It is gratifying to know that our vision of combining theory, pedagogy, and design to exemplify how statistics is used to picture and describe the world has helped students learn about statistics and make informed decisions.

New to the Third Edition

Chapter Openers Chapter openers have been updated. Each chapter opener provides a road map for the chapter and begins with a two-page visual description of a real-life problem that is often revisited in the chapter. The chapter opener shows students how the chapter fits into the bigger picture of statistics by connecting it to topics learned in earlier chapters and then gives an overview of the chapter in the context of the real-world data presented.

Interpretation Examples are solved in a step-by-step manner, and students are asked to reflect upon conclusion of the example in an Interpretation step. This added step promotes critical thinking and writing skills.

Exercises The exercise sets in the Third Edition include about 1900 exercises, giving students practice in performing calculations, making decisions, providing explanations, and applying results to a real-life setting. Approximately 35% of these exercises are new or revised. The exercises are divided into three sections:

Building Basic Skills and Vocabulary Each exercise set begins with a group of exercises called *Building Basic Skills and Vocabulary*. These exercises are short answer, true and false, or vocabulary carefully written to nurture student understanding.

NEW! ***Using and Interpreting Concepts*** Each exercise set contains a group of exercises called *Using and Interpreting Concepts*. These exercises are skill or word problems carefully written to nurture student understanding and proficiency. They move from basic skill development to more challenging and interpretive problems.

Extending Concepts Each exercise set ends with a group of exercises called *Extending Concepts*. These exercises go beyond the material presented in the section—they tend to be more challenging and are not required as prerequisites of subsequent sections.

Round off Rules Round off rules have been included in Study Tips at point of use. These rules guide the student during calculations.

Course Coverage In response to suggestions from statistics instructors, the coverage of topics in Chapters 4, 5, 7, 9, and 11 is revised in the Third Edition. Many of these changes emphasize interpretation of results rather than calculations.

- **In Chapter 4,** additional exercises place more emphasis on mean and standard deviation of binomial distributions. Also, more emphasis is placed on identification of unusual values within this distribution.

- **In Chapter 5,** we combined two sections to form Section 5.1 **Introduction to Normal Distributions and the Standard Normal Distribution.** This section replaces Section 5.1 **Introduction to Normal Distributions** and Section 5.2 **The Standard Normal Distribution** in the Second Edition. The Empirical Rule has been covered in Chapter 2, so there is no need for it in Chapter 5. In Section 5.4, **Sampling Distributions and the Central Limit Theorem,** more emphasis is placed on identifying unusual values within sampling distributions.
- **In Chapter 7,** we have placed more emphasis on the logic behind the hypotheses testing process and interpreting the decision.
- **In Chapter 9,** for instructors who prefer to cover Section 9.1, **Correlation,** immediately after covering graphing paired data in Chapter 2, we present a method for testing a population correlation coefficient that does not involve hypothesis testing. The method is simple and can easily be covered after Chapters 1 and 2.
- **In Chapter 11,** we added a new section—Section 11.5 **Runs Test.** This section provides students with a method—a nonparametric test called the Runs Test—for testing randomness in a set of data.

Continuing Strong Pedagogy from the Second Edition

Versatile Course Coverage The table of contents of the text was developed to give instructors many options. For instance, assigning the *Extending Concepts* exercises and spending time on the chapter projects provide sufficient content to use the text in a two-semester course. More commonly, we expect the text to be used in a three-credit semester course or a four-credit semester course that includes a lab component. In such cases, instructors will have to pare down the text's 46 sections. If you wish to view sample syllabi, you can access these within **MyMathLab** under the Instructor Resource Area.

Graphical Approach As with most introductory statistics texts, we begin the descriptive statistics chapter with a survey of different ways to display data graphically. A difference between this text and many others is that **we continue to incorporate the graphical display of data throughout the text.** For example, see the use of stem-and-leaf plots to display data on pages 362 and 363. This emphasis on graphical displays is beneficial to all students, especially those utilizing visual learning strategies.

Balanced Approach The text strikes a **balance between computation, decision making, and conceptual understanding.** We have provided many Examples, Exercises, and Try It Yourself exercises that go beyond mere computation. For instance, look at Exercises 31–34 on page 257. Students are not just asked to calculate a probability; they also are asked to use the probability to make a decision about a claim.

Variety of Real-Life Applications We have chosen real-life applications that are representative of the majors of students taking introductory statistics courses. These include business, psychology, health sciences, sports, computer science, political science, and many others. Choosing meaningful applications for such a diverse audience is difficult. We want statistics to come alive and appear

relevant to students so they understand the importance and rationale for studying statistics. We wanted the applications to be **authentic**—but they also need to be **accessible.** See the Index of Applications on page xxiii.

Data and Source Lines The data sets in the book were chosen for interest, variety, and their ability to illustrate concepts. Most of the **over 200 data sets** contain actual data with source lines. The remaining data sets contain simulated data that are representative of real-life situations. All data sets containing 20 or more entries are available in a variety of electronic forms, including disk and Internet. In the exercise sets, the data sets that are available electronically are indicated by the icon 

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Flexible Technology Although most formulas in the book are illustrated with tabular "hand" calculations, we assume that most students who take this course have access to some form of technology tool, such as MINITAB, Excel, the TI-83, or SPSS. Because the use of technology varies widely, we have made the text flexible. **It can be used in courses with no more technology than a scientific calculator—or it can be used in courses that require frequent use of sophisticated technology tools.** For those who want specific instructions on particular technology tools, separate technology manuals are available to augment the text. Whatever your use of technology, we are sure that you agree with us that the goal of the course is not computation. Rather, it is to gain an understanding of the basic concepts and uses of statistics.

Prerequisites Statistics contains many formulas and variables, including radicals, summation notation, Greek letters, and subscripts. So, **some familiarity with algebra and evaluation of algebraic expressions** is a prerequisite. Nevertheless, we have made every effort to keep algebraic manipulations to a minimum—often we display informal versions of formulas using words in place of or in addition to variables. For instance, see the definitions of midpoint and relative frequency on page 36.

Choice of Tables Our experience has shown that students find a **cumulative density function** (CDF) table easier to use than a "0-to-z" table. Using the CDF table to find the area under a normal curve is a topic of Section 5.1 on pages 219–223. Because we realize that many teachers prefer to use the "0-to-z" table, we have provided an alternative presentation of this topic using the "0-to-z" table in Appendix A of the book.

MAA, AMATYC, NCTM Standards This text answers the call for a **student-friendly text that emphasizes the uses of statistics** and not just the computation of its myriad formulas. Our experience indicates that our job as instructors of an introductory course in statistics is not to produce statisticians but to produce informed consumers of statistical reports. For this reason, we have included many exercises that require students to provide written explanations, find patterns, and make decisions.

Page Layout We believe that statistics is more accessible to students when it is carefully formatted on each page with a consistent open layout. This text is the first college-level statistics book to be written to design, which means that its features (Examples, Try It problems, Definitions, or Guidelines) are not split from one page to the next. Although this process requires extra planning and work in the development stage, the result is a presentation that is clean and clear.

Supplements

Student Resources

Student Study Pack

(Stand-alone: 0-13-134367-X; Value Pack: 0-13-136366-1)

Everything a student needs to succeed in one place. Free packaged with the book, or available for purchase stand-alone. The **Student Study Pack** contains:

- **Chapter Quiz Prep Video (CD-ROM)** Provides step-by-step video solutions to every problem in the textbook *Chapter Quizzes*.
- **Student Solutions Manual** Includes complete worked-out solutions to all of the *Try It Yourself* exercises, the odd-numbered exercises, and all of the *Chapter Quiz* exercises.
- **CD Lecture Series** A comprehensive set of CD-ROMs, tied to the textbook, containing short video clips of an instructor working every *Try It Yourself* exercise.
- **Technology Manuals** Tutorial instruction and worked-out examples for the TI-83 Calculator, Excel, and MINITAB.
- **Pearson Tutor Center** Tutors provide one-on-one tutoring for any problem with an answer at the back of the book. Students access the Tutor Center via toll-free phone, fax, or email.

Instructor Resources

Content Distribution Center

All instructor resources can be downloaded from Prentice Hall website *www.prenhall.com* (then search for Larson/Farber, *Elementary Statistics 3e*). This is a password-protected website that requires instructors to set up an account or, alternatively, instructor resources can be ordered individually from your Prentice Hall sales representative:

- **Instructor-to-Instructor CD Lecture Video** (0-13-186162-X) Offers classroom suggestions, time-saving tips, and strategies for engaging students and presenting key topics throughout the course.
- **Instructor Solutions Manual** (0-13-148318-8) Includes complete solutions to all of the exercises, *Try It Yourself* exercises, Case Studies, Technology pages, Uses and Abuses exercises, and Real Statistics-Real Decisions exercises.
- **TestGen** (0-13-148320-X) Test-generating software—create tests from textbook section objectives. Includes more than 1050 additional questions with an answer key. Questions are algorithmically generated, allowing for unlimited test versions. Instructors may also edit problems or create their own.
- **Test Item File** (0-13-148319-6) A printed test bank derived from TestGen.
- **PowerPoint Lecture Slides** Fully editable and printable slides that follow the textbook. Use during lecture or post to a website in an online course. Most slides include notes offering suggestions for how the material may effectively be presented in class.

Annotated Instructor's Edition

Includes:

- *Notes to Instructors* appear in the margin of the text to suggest activities that correspond to the example or concept, additional ways to present the material, common pitfalls students encounter, alternative formulas or approaches that may be used, and other helpful teaching tips for instructors.
- All answers to the section and review exercises are provided with short answers (numerical, tabular, and/or graphical) appearing in the margin next to the exercise.

Internet Resources

MyMathLab

(Student: 0-13-147894-X; Instructor: 0-13-147898-2)

MyMathLab is a text-specific, online course. MyMathLab contains MathXL (Internet) at its core, providing all of the tutorial, homework, testing, and diagnostic power of MathXL. Beyond the power of MathXL, you also get access to

- **Course Management Tools** MyMathLab is a fully functioning course management system. Upload documents (e.g., syllabi, lecture notes, etc.) utilize communication tools (e.g., email, chat rooms, virtual classroom), create and post assignments, and more.
- **Additional Resources for Instructors and Students** Access a multimedia textbook, online lecture videos, solutions manuals, online graphing calculator manual, sample syllabi, a video on overcoming math anxiety, PowerPoint lecture slides, and more.

MathXL® (Internet)

A powerful online homework, tutorial, and assessment system. MathXL (Internet) provides powerful tutorial capabilities and allows instructors to create, edit, and assign online homework and tests (built from provided text-specific question banks) and to track student work in a gradebook. MathXL creates study plans personalized for students on the basis of test results.

Acknowledgments

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Agnes Tuska, California State University–Fresno
Ting-Xiu Wang, Oakton Community College
Dex Whittinghill, Rowan University

Third Edition Reviewers

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Elisabeth Schuster, Benedictine University
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Aileen Solomon, Trident Technical College
Kathleen Suchora, University of Central Florida

Accuracy Checker

Sarah Streett

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We also thank the staff of Larson Texts, Inc., who assisted with the development and production of the book.

On a personal level, we are grateful to our spouses, Deanna Gilbert Larson and Richard Farber, for their love, patience, and support. Also, a special thanks goes to R. Scott O'Neil.

We have worked hard to make *Elementary Statistics: Picturing the World*, Third Edition, a clean, clear, and enjoyable text from which to teach and learn statistics. Despite our best efforts to ensure accuracy and ease of use, many users will undoubtedly have suggestions for improvement. We welcome your suggestions.

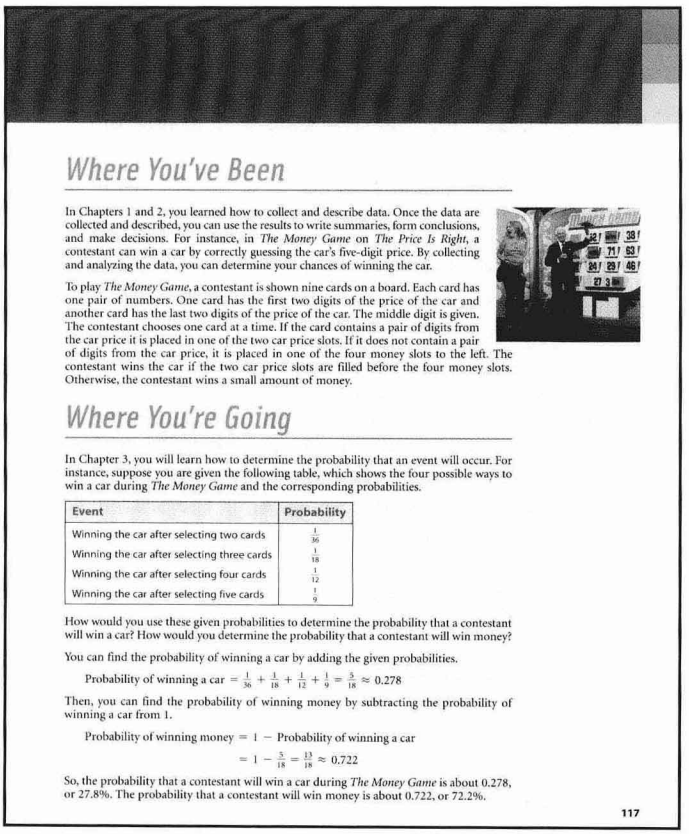
Ron Larson

Ron Larson, odx@psu.edu

Betsy Farber

Betsy Farber, farberb@bucks.edu

Features



Where You've Been

In Chapters 1 and 2, you learned how to collect and describe data. Once the data are collected and described, you can use the results to write summaries, form conclusions, and make decisions. For instance, in *The Money Game* on *The Price Is Right*, a contestant can win a car by correctly guessing the car's five-digit price. By collecting and analyzing the data, you can determine your chances of winning the car.

To play *The Money Game*, a contestant is shown nine cards on a board. Each card has one pair of numbers. One card has the first two digits of the price of the car and another card has the last two digits of the price of the car. The middle digit is given. The contestant chooses one card at a time. If the card contains a pair of digits from the car price it is placed in one of the two car price slots. If it does not contain a pair of digits from the car price, it is placed in one of the four money slots to the left. The contestant wins the car if the two car price slots are filled before the four money slots. Otherwise, the contestant wins a small amount of money.

Where You're Going

In Chapter 3, you will learn how to determine the probability that an event will occur. For instance, suppose you are given the following table, which shows the four possible ways to win a car during *The Money Game* and the corresponding probabilities.

Event	Probability
Winning the car after selecting two cards	$\frac{1}{36}$
Winning the car after selecting three cards	$\frac{1}{18}$
Winning the car after selecting four cards	$\frac{1}{12}$
Winning the car after selecting five cards	$\frac{1}{9}$

How would you use these given probabilities to determine the probability that a contestant will win a car? How would you determine the probability that a contestant will win money?

You can find the probability of winning a car by adding the given probabilities.

$$\text{Probability of winning a car} = \frac{1}{36} + \frac{1}{18} + \frac{1}{12} + \frac{1}{9} = \frac{5}{18} \approx 0.278$$

Then, you can find the probability of winning money by subtracting the probability of winning a car from 1.

$$\text{Probability of winning money} = 1 - \text{Probability of winning a car}$$
$$= 1 - \frac{5}{18} = \frac{13}{18} \approx 0.722$$

So, the probability that a contestant will win a car during *The Money Game* is about 0.278, or 27.8%. The probability that a contestant will win money is about 0.722, or 72.2%.

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Chapter Openers

Where You've Been

Each chapter begins with a two-page photographic description of a real-life problem. The feature called *Where You've Been* shows students how the chapter fits into the bigger picture of statistics, by connecting it to topics learned in earlier chapters.

Where You're Going

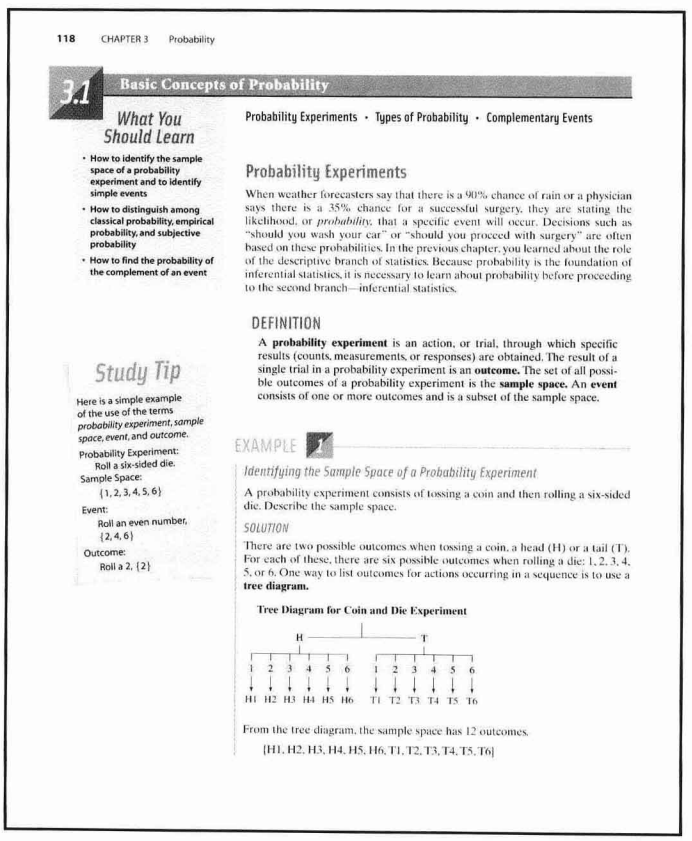
The feature called *Where You're Going* gives students an overview of the chapter, exploring concepts in the context of real-world settings.

Section Organization

Each section is organized by learning objectives. These objectives are presented in everyday language in a margin feature called *What You Should Learn*. The same objectives are then used as subsection titles throughout the section.

Study Tips

Most sections contain one or more study tips placed on "sticky notes" in the margin. These tend to be informal learning aids, which show how to read a table, use technology, or interpret a result or a graph.



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3.1 Basic Concepts of Probability

What You Should Learn

- How to identify the sample space of a probability experiment and to identify simple events
- How to distinguish among classical probability, empirical probability, and subjective probability
- How to find the probability of the complement of an event

Probability Experiments • Types of Probability • Complementary Events

Probability Experiments

When weather forecasters say that there is a 90% chance of rain or a physician says there is a 35% chance for a successful surgery, they are stating the likelihood, or *probability*, that a specific event will occur. Decisions such as "should you wash your car" or "should you proceed with surgery" are often based on these probabilities. In the previous chapter, you learned about the role of the descriptive branch of statistics. Because probability is the foundation of inferential statistics, it is necessary to learn about probability before proceeding to the second branch—inferential statistics.

DEFINITION

A **probability experiment** is an action, or trial, through which specific results (counts, measurements, or responses) are obtained. The result of a single trial in a probability experiment is an **outcome.** The set of all possible outcomes of a probability experiment is the **sample space.** An **event** consists of one or more outcomes and is a subset of the sample space.

Study Tip

Here is a simple example of the use of the terms *probability experiment, sample space, event,* and *outcome.*

Probability Experiment:
Roll a six-sided die.
Sample Space:
{1, 2, 3, 4, 5, 6}
Event:
Roll an even number.
{2, 4, 6}
Outcome:
Roll a 2. {2}

EXAMPLE 1

Identifying the Sample Space of a Probability Experiment

A probability experiment consists of tossing a coin and then rolling a six-sided die. Describe the sample space.

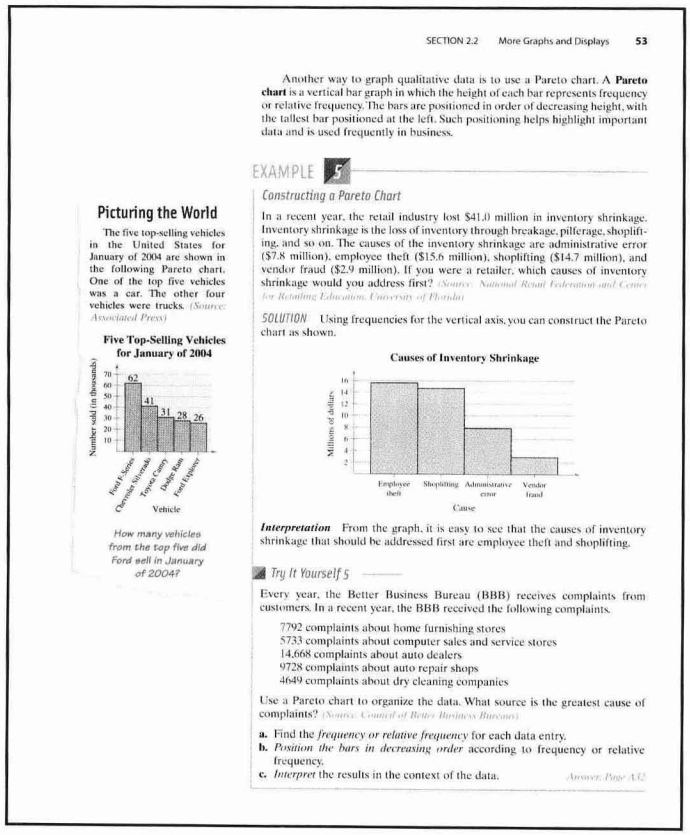
SOLUTION

There are two possible outcomes when tossing a coin, a head (H) or a tail (T). For each of these, there are six possible outcomes when rolling a die: 1, 2, 3, 4, 5, or 6. One way to list outcomes for actions occurring in a sequence is to use a **tree diagram.**

Tree Diagram for Coin and Die Experiment

From the tree diagram, the sample space has 12 outcomes.

{H1, H2, H3, H4, H5, H6, T1, T2, T3, T4, T5, T6}



SECTION 2.2 More Graphs and Displays 53

Another way to graph qualitative data is to use a Pareto chart. A **Pareto chart** is a vertical bar graph in which the height of each bar represents frequency or relative frequency. The bars are positioned in order of decreasing height, with the tallest bar positioned at the left. Such positioning helps highlight important data and is used frequently in business.

Picturing the World

The five top-selling vehicles in the United States for January of 2004 are shown in the following Pareto chart. One of the top five vehicles was a car. The other four vehicles were trucks. *(Source: Associated Press)*

Five Top-Selling Vehicles for January of 2004

How many vehicles from the top five did Ford sell in January of 2004?

EXAMPLE 5

Constructing a Pareto Chart

In a recent year, the retail industry lost $41.0 million in inventory shrinkage. Inventory shrinkage is the loss of inventory through breakage, pilferage, shoplifting, and so on. The causes of the inventory shrinkage are administrative error ($7.8 million), employee theft ($15.6 million), shoplifting ($14.7 million), and vendor fraud ($2.9 million). If you were a retailer, which causes of inventory shrinkage would you address first? *(Source: National Retail Federation and Center for Retailing Education, University of Florida)*

SOLUTION Using frequencies for the vertical axis, you can construct the Pareto chart as shown.

Interpretation From the graph, it is easy to see that the causes of inventory shrinkage that should be addressed first are employee theft and shoplifting.

Try It Yourself 5

Every year, the Better Business Bureau (BBB) receives complaints from customers. In a recent year, the BBB received the following complaints.

7792 complaints about home furnishing stores
5733 complaints about computer sales and service stores
14,668 complaints about auto dealers
9728 complaints about auto repair shops
4649 complaints about dry cleaning companies

Use a Pareto chart to organize the data. What source is the greatest cause of complaints? *(Source: Council of Better Business Bureaus)*

a. Find the *frequency or relative frequency* for each data entry.
b. *Position the bars in decreasing order* according to frequency or relative frequency.
c. *Interpret* the results in the context of the data.

Answer: Page A32

Picturing the World

Each section contains a real-life "mini case study" that illustrates the important concept or concepts of the section. Each *Picturing the World* concludes with a question and can be used for general class discussion or group work.

Definitions

The critical statistics definitions are set off with screens. Formal definitions are often followed by guidelines that explain, in everyday English, how to apply the definition.

Guidelines

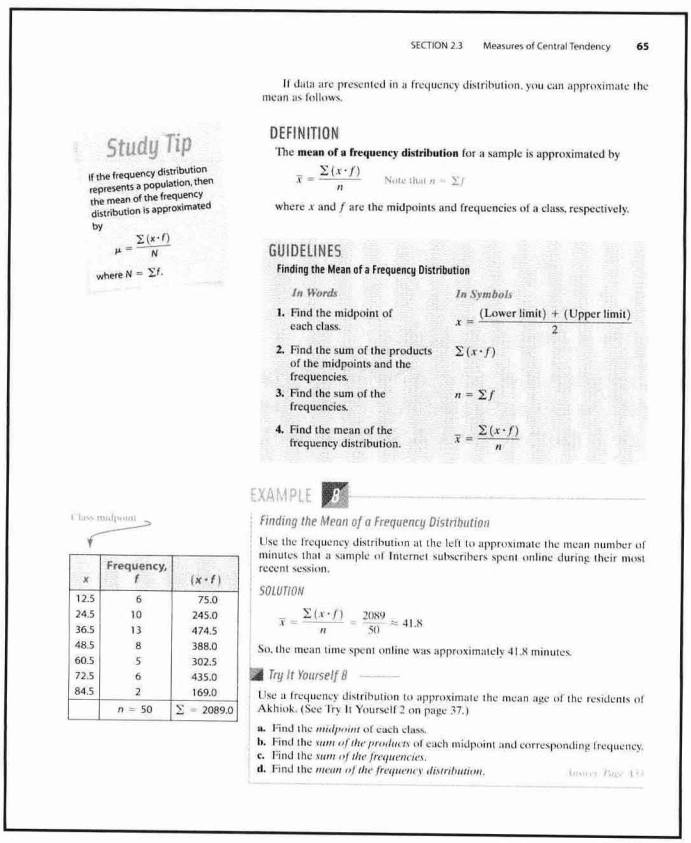
Throughout the book, the presentation of a statistical formula is followed by a set of step-by-step guidelines for applying the formula. The guidelines are divided into two columns titled *In Words* and *In Symbols*.

Titled Examples

Every concept in the text is clearly illustrated with one or more step-by-step examples. Many examples have an interpretation step that shows the student how the solution may be interpreted within the real-life context of the example. Each of the more than 200 examples is numbered and titled for easy reference. In presenting the examples, we use an open format with a step-by-step display that students can use as a model when solving the exercises.

Try It Yourself

Each example in the text is followed by a similar exercise called *Try It Yourself*. Students can immediately practice the skill learned in the example. The answers to these exercises are given in the back of the book, and the worked-out solutions are given in the *Student's Solutions Manual*. The accompanying CD Lecture Videos contain clips of an instructor working out each *Try It Yourself* exercise.



SECTION 2.3 Measures of Central Tendency 65

If data are presented in a frequency distribution, you can approximate the mean as follows.

Study Tip

If the frequency distribution represents a population, then the mean of the frequency distribution is approximated by

$$\mu = \frac{\Sigma(x \cdot f)}{N}$$

where $N = \Sigma f$.

DEFINITION

The **mean of a frequency distribution** for a sample is approximated by

$$\bar{x} = \frac{\Sigma(x \cdot f)}{n} \quad \text{Note that } n = \Sigma f$$

where x and f are the midpoints and frequencies of a class, respectively.

GUIDELINES

Finding the Mean of a Frequency Distribution

In Words	*In Symbols*
1. Find the midpoint of each class.	$x = \frac{(\text{Lower limit}) + (\text{Upper limit})}{2}$
2. Find the sum of the products of the midpoints and the frequencies.	$\Sigma(x \cdot f)$
3. Find the sum of the frequencies.	$n = \Sigma f$
4. Find the mean of the frequency distribution.	$\bar{x} = \frac{\Sigma(x \cdot f)}{n}$

EXAMPLE 8

Finding the Mean of a Frequency Distribution

Use the frequency distribution at the left to approximate the mean number of minutes that a sample of Internet subscribers spent online during their most recent session.

Class midpoint

x	Frequency, f	$(x \cdot f)$
12.5	6	75.0
24.5	10	245.0
36.5	13	474.5
48.5	8	388.0
60.5	5	302.5
72.5	6	435.0
84.5	2	169.0
	$n = 50$	$\Sigma = 2089.0$

SOLUTION

$$\bar{x} = \frac{\Sigma(x \cdot f)}{n} = \frac{2089}{50} \approx 41.8$$

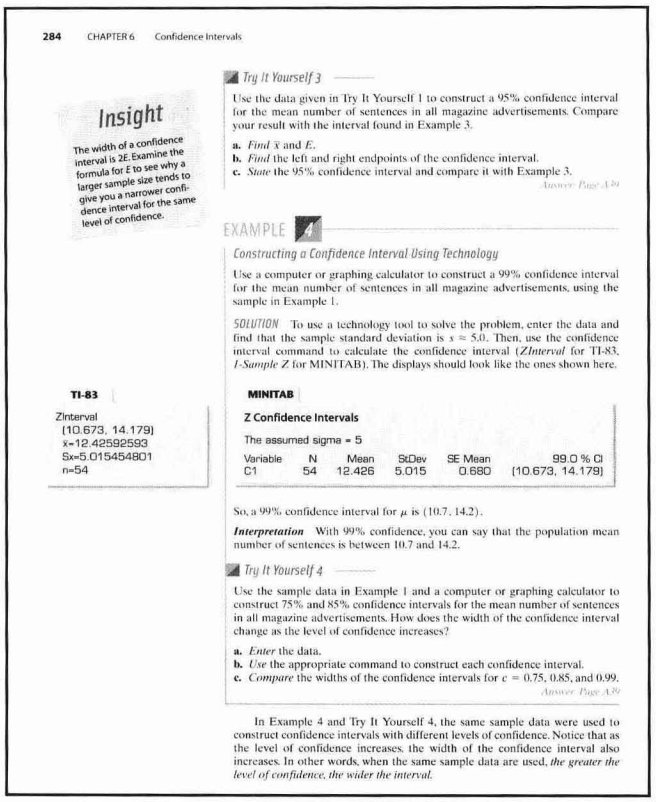
So, the mean time spent online was approximately 41.8 minutes.

Try It Yourself 8

Use a frequency distribution to approximate the mean age of the residents of Akhiok. (See Try It Yourself 2 on page 37.)

a. Find the *midpoint* of each class.
b. Find the *sum of the products* of each midpoint and corresponding frequency.
c. Find the *sum of the frequencies*.
d. Find the *mean of the frequency distribution*.

Answer: Page A33



284 CHAPTER 6 Confidence Intervals

Insight

The width of a confidence interval is 2*E*. Examine the formula for *E* to see why a larger sample size tends to give you a narrower confidence interval for the same level of confidence.

Try It Yourself 3

Use the data given in Try It Yourself 1 to construct a 95% confidence interval for the mean number of sentences in all magazine advertisements. Compare your result with the interval found in Example 3.

a. *Find* $\bar{x}$ and E.
b. *Find* the left and right endpoints of the confidence interval.
c. *State* the 95% confidence interval and compare it with Example 3.

Answer Page A-39

EXAMPLE 4

Constructing a Confidence Interval Using Technology

Use a computer or graphing calculator to construct a 99% confidence interval for the mean number of sentences in all magazine advertisements, using the sample in Example 1.

SOLUTION To use a technology tool to solve the problem, enter the data and find that the sample standard deviation is $s = 5.0$. Then, use the confidence interval command to calculate the confidence interval (*ZInterval* for TI-83, *1-Sample Z* for MINITAB). The displays should look like the ones shown here.

TI-83

ZInterval
(10.673, 14.179)
$\bar{x}$=12.42592593
Sx=5.01545801
n=54

MINITAB

Z Confidence Intervals

The assumed sigma = 5

Variable	N	Mean	StDev	SE Mean	99.0 % CI
C1	54	12.426	5.015	0.680	(10.673, 14.179)

So, a 99% confidence interval for μ is (10.7, 14.2).

Interpretation With 99% confidence, you can say that the population mean number of sentences is between 10.7 and 14.2.

Try It Yourself 4

Use the sample data in Example 1 and a computer or graphing calculator to construct 75% and 85% confidence intervals for the mean number of sentences in all magazine advertisements. How does the width of the confidence interval change as the level of confidence increases?

a. *Enter* the data.
b. *Use* the appropriate command to construct each confidence interval.
c. *Compare* the widths of the confidence intervals for $c = 0.75$, 0.85, and 0.99.

Answer Page A-39

In Example 4 and Try It Yourself 4, the same sample data were used to construct confidence intervals with different levels of confidence. Notice that as the level of confidence increases, the width of the confidence interval also increases. In other words, when the same sample data are used, *the greater the level of confidence, the wider the interval.*

Section Exercise Sets

The section exercises are split into three categories, listed below. The exercises build from basic skill development to more challenging and interpretive problems. Most exercises are labeled for easy reference. Exercises labeled *Graphical Analysis* ask students to use the graphs provided to answer the questions. Almost all exercises are given in "paired format" so that the odd-numbered exercise, whose answer is given in the back of the book, is paired with an even-numbered exercise, whose answer is not given.

Building Basic Skills and Vocabulary These exercises are short answer, true and false, or vocabulary for students to test their knowledge of vocabulary and concepts from the section.

Using and Interpreting Concepts These exercises are skill or word problems carefully written to nurture student understanding and proficiency.

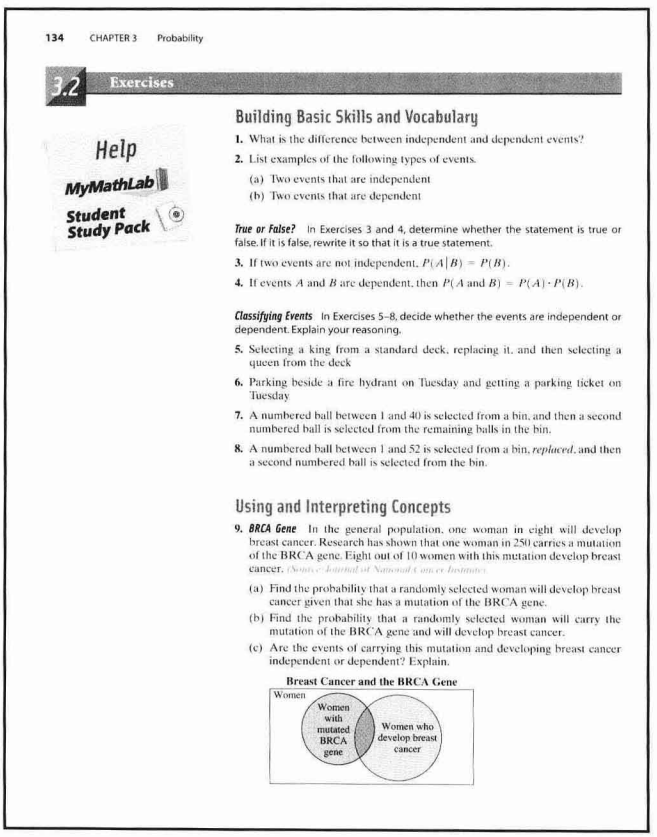
Extending Concepts These exercises go beyond the material presented in the section—they tend to be more challenging and are not required as prerequisites of subsequent sections.

Technology Examples

Many sections contain a worked example that shows how technology can be used to calculate formulas, perform tests, or display data. Screen displays from MINITAB, Excel, and TI-83 are given. Additional screen displays are given at the ends of selected chapters, and detailed instructions are given in separate technology manuals available with the book.

Insights

Most sections also contain one or more insights placed on blue "sticky notes" in the margin. The purpose of each insight is to help drive home an important interpretation or help connect different concepts.



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3.2 Exercises

Help
MyMathLab
Student Study Pack

Building Basic Skills and Vocabulary

1. What is the difference between independent and dependent events?
2. List examples of the following types of events.
   (a) Two events that are independent
   (b) Two events that are dependent

True or False? In Exercises 3 and 4, determine whether the statement is true or false. If it is false, rewrite it so that it is a true statement.

3. If two events are not independent, $P(A|B) = P(B)$.
4. If events A and B are dependent, then $P(A \text{ and } B) = P(A) \cdot P(B)$.

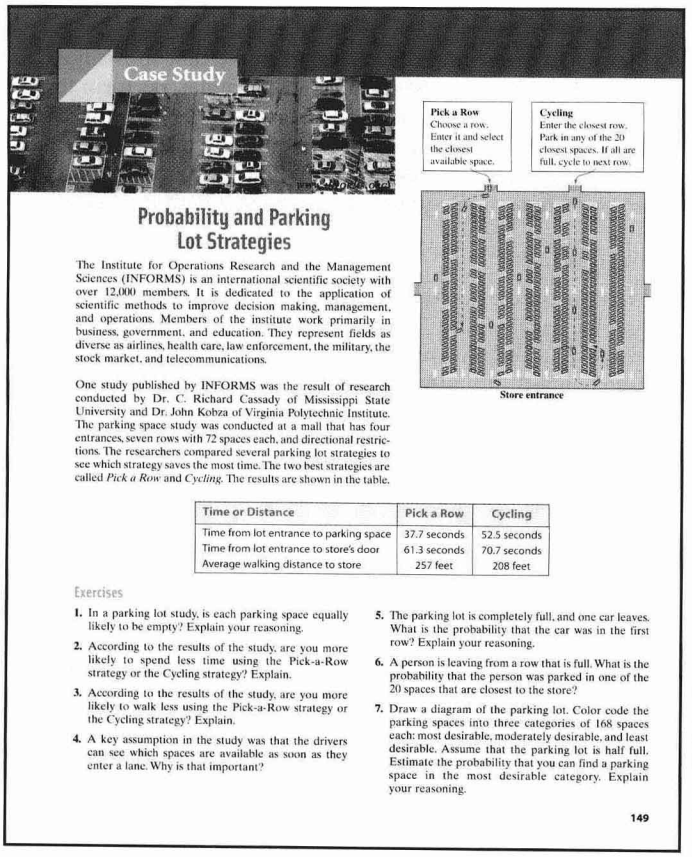
Classifying Events In Exercises 5–8, decide whether the events are independent or dependent. Explain your reasoning.

5. Selecting a king from a standard deck, replacing it, and then selecting a queen from the deck
6. Parking beside a fire hydrant on Tuesday and getting a parking ticket on Tuesday
7. A numbered ball between 1 and 40 is selected from a bin, and then a second numbered ball is selected from the remaining balls in the bin.
8. A numbered ball between 1 and 52 is selected from a bin, *replaced*, and then a second numbered ball is selected from the bin.

Using and Interpreting Concepts

9. ***BRCA Gene*** In the general population, one woman in eight will develop breast cancer. Research has shown that one woman in 250 carries a mutation of the BRCA gene. Eight out of 10 women with this mutation develop breast cancer. (Source: Journal of National Cancer Institute)
   (a) Find the probability that a randomly selected woman will develop breast cancer given that she has a mutation of the BRCA gene.
   (b) Find the probability that a randomly selected woman will carry the mutation of the BRCA gene and will develop breast cancer.
   (c) Are the events of carrying this mutation and developing breast cancer independent or dependent? Explain.

Breast Cancer and the BRCA Gene



Case Study

Probability and Parking Lot Strategies

The Institute for Operations Research and the Management Sciences (INFORMS) is an international scientific society with over 12,000 members. It is dedicated to the application of scientific methods to improve decision making, management, and operations. Members of the institute work primarily in business, government, and education. They represent fields as diverse as airlines, health care, law enforcement, the military, the stock market, and telecommunications.

One study published by INFORMS was the result of research conducted by Dr. C. Richard Cassady of Mississippi State University and Dr. John Kobza of Virginia Polytechnic Institute. The parking space study was conducted at a mall that has four entrances, seven rows with 72 spaces each, and directional restrictions. The researchers compared several parking lot strategies to see which strategy saves the most time. The two best strategies are called *Pick a Row* and *Cycling*. The results are shown in the table.

Time or Distance	Pick a Row	Cycling
Time from lot entrance to parking space	37.7 seconds	52.5 seconds
Time from lot entrance to store's door	61.3 seconds	70.7 seconds
Average walking distance to store	257 feet	208 feet

Exercises

1. In a parking lot study, is each parking space equally likely to be empty? Explain your reasoning.
2. According to the results of the study, are you more likely to spend less time using the Pick-a-Row strategy or the Cycling strategy? Explain.
3. According to the results of the study, are you more likely to walk less using the Pick-a-Row strategy or the Cycling strategy? Explain.
4. A key assumption in the study was that the drivers can see which spaces are available as soon as they enter a lane. Why is that important?
5. The parking lot is completely full, and one car leaves. What is the probability that the car was in the first row? Explain your reasoning.
6. A person is leaving from a row that is full. What is the probability that the person was parked in one of the 20 spaces that are closest to the store?
7. Draw a diagram of the parking lot. Color code the parking spaces into three categories of 168 spaces each: most desirable, moderately desirable, and least desirable. Assume that the parking lot is half full. Estimate the probability that you can find a parking space in the most desirable category. Explain your reasoning.

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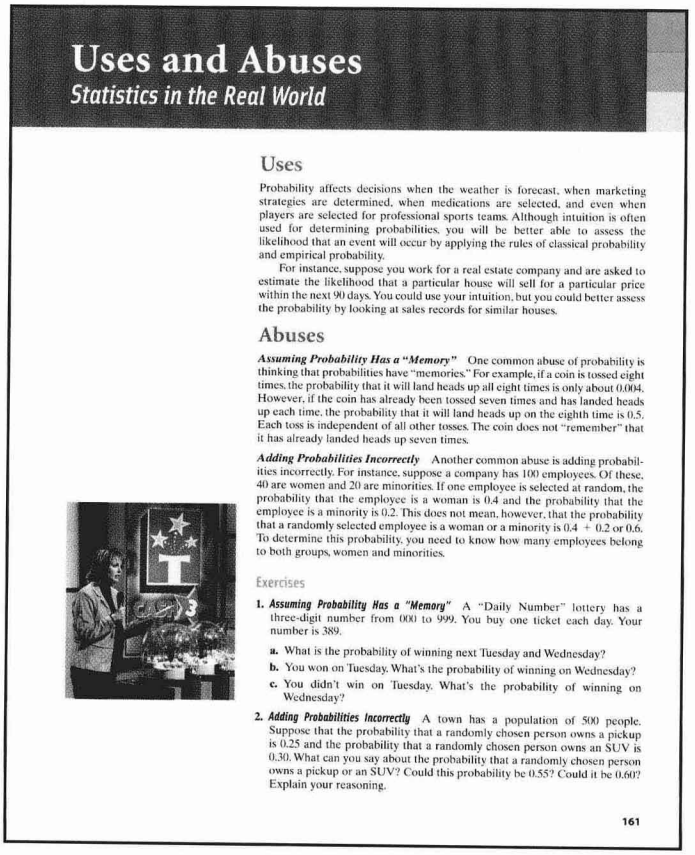
Chapter Case Study

Each chapter has a full-page Case Study featuring actual data from a real-world context and a series of thought-provoking questions that are designed to illustrate the important concepts of the chapter.

Uses and Abuses: Statistics in the Real World

Each chapter features an expanded discussion on how statistical techniques should be used, while cautioning students about common abuses. Exercises help students to apply their knowledge.



Uses and Abuses

Statistics in the Real World

Uses

Probability affects decisions when the weather is forecast, when marketing strategies are determined, when medications are selected, and even when players are selected for professional sports teams. Although intuition is often used for determining probabilities, you will be better able to assess the likelihood that an event will occur by applying the rules of classical probability and empirical probability.

For instance, suppose you work for a real estate company and are asked to estimate the likelihood that a particular house will sell for a particular price within the next 90 days. You could use your intuition, but you could better assess the probability by looking at sales records for similar houses.

Abuses

Assuming Probability Has a "Memory" One common abuse of probability is thinking that probabilities have "memories." For example, if a coin is tossed eight times, the probability that it will land heads up all eight times is only about 0.004. However, if the coin has already been tossed seven times and has landed heads up each time, the probability that it will land heads up on the eighth time is 0.5. Each toss is independent of all other tosses. The coin does not "remember" that it has already landed heads up seven times.

Adding Probabilities Incorrectly Another common abuse is adding probabilities incorrectly. For instance, suppose a company has 100 employees. Of these, 40 are women and 20 are minorities. If one employee is selected at random, the probability that the employee is a woman is 0.4 and the probability that the employee is a minority is 0.2. This does not mean, however, that the probability that a randomly selected employee is a woman or a minority is 0.4 + 0.2 or 0.6. To determine this probability, you need to know how many employees belong to both groups, women and minorities.

Exercises

1. ***Assuming Probability Has a "Memory"*** A "Daily Number" lottery has a three-digit number from 000 to 999. You buy one ticket each day. Your number is 389.
   a. What is the probability of winning next Tuesday and Wednesday?
   b. You won on Tuesday. What's the probability of winning on Wednesday?
   c. You didn't win on Tuesday. What's the probability of winning on Wednesday?
2. ***Adding Probabilities Incorrectly*** A town has a population of 500 people. Suppose that the probability that a randomly chosen person owns a pickup is 0.25 and the probability that a randomly chosen person owns an SUV is 0.30. What can you say about the probability that a randomly chosen person owns a pickup or an SUV? Could this probability be 0.55? Could it be 0.60? Explain your reasoning.

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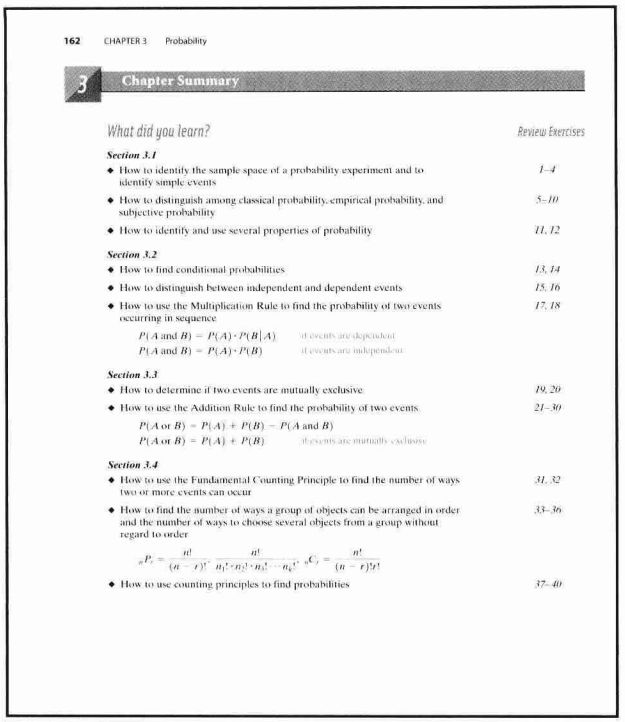


162 CHAPTER 3 Probability

3 Chapter Summary

What did you learn? — *Review Exercises*

Section 3.1

- How to identify the sample space of a probability experiment and to identify simple events — *1–4*
- How to distinguish among classical probability, empirical probability, and subjective probability — *5–10*
- How to identify and use several properties of probability — *11, 12*

Section 3.2

- How to find conditional probabilities — *13, 14*
- How to distinguish between independent and dependent events — *15, 16*
- How to use the Multiplication Rule to find the probability of two events occurring in sequence — *17, 18*

$P(A \text{ and } B) = P(A) \cdot P(B|A)$ if events are dependent
$P(A \text{ and } B) = P(A) \cdot P(B)$ if events are independent

Section 3.3

- How to determine if two events are mutually exclusive — *19, 20*
- How to use the Addition Rule to find the probability of two events — *21–30*

$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
$P(A \text{ or } B) = P(A) + P(B)$ if events are mutually exclusive

Section 3.4

- How to use the Fundamental Counting Principle to find the number of ways two or more events can occur — *31, 32*
- How to find the number of ways a group of objects can be arranged in order and the number of ways to choose several objects from a group without regard to order — *33–36*

$${}_nP_r = \frac{n!}{(n-r)!} \quad \frac{n!}{n_1! \cdot n_2! \cdot n_3! \cdots n_k!} \quad {}_nC_r = \frac{n!}{(n-r)!r!}$$

- How to use counting principles to find probabilities — *37–40*

Chapter Summary

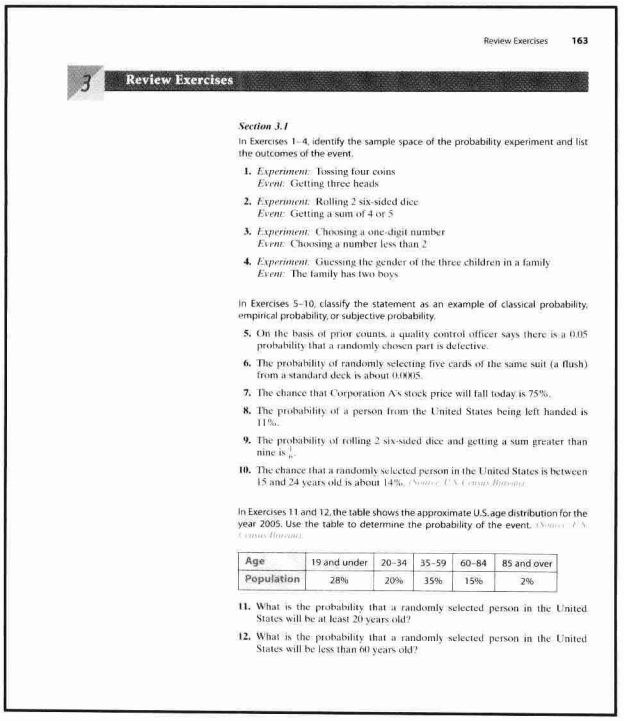
Each chapter concludes with a Chapter Summary that answers the question *What did you learn?* This can be used as a study aid in conjunction with the chapter Review Exercises.

Chapter Review Exercises

A set of Review Exercises follows each Chapter Summary. The order of the exercises follows the chapter organization. Answers to all odd-numbered exercises are given in the back of the book. Worked-out solutions are available in the *Student's Solutions Manual.*

Chapter Quizzes

Each chapter ends with a Chapter Quiz. The answers to all quiz questions are provided in the back of the book. For additional help, see the step-by-step video solutions on the Chapter Quiz Prep Video.



Review Exercises 163

3 Review Exercises

Section 3.1

In Exercises 1–4, identify the sample space of the probability experiment and list the outcomes of the event.

1. *Experiment:* Tossing four coins
   Event: Getting three heads
2. *Experiment:* Rolling 2 six-sided dice
   Event: Getting a sum of 4 or 5
3. *Experiment:* Choosing a one-digit number
   Event: Choosing a number less than 2
4. *Experiment:* Guessing the gender of the three children in a family
   Event: The family has two boys

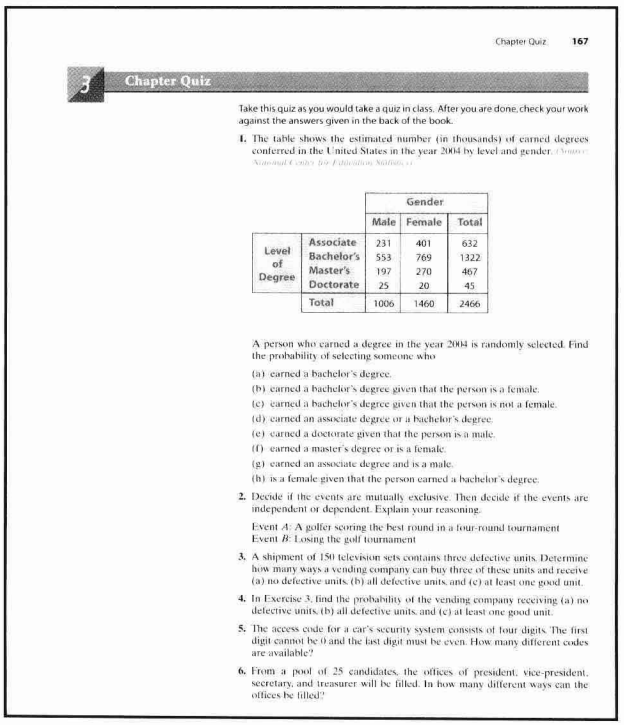
In Exercises 5–10, classify the statement as an example of classical probability, empirical probability, or subjective probability.

5. On the basis of prior counts, a quality control officer says there is a 0.05 probability that a randomly chosen part is defective.
6. The probability of randomly selecting five cards of the same suit (a flush) from a standard deck is about 0.0005.
7. The chance that Corporation AX's stock price will fall today is 75%.
8. The probability of a person from the United States being left handed is 11%.
9. The probability of rolling 2 six-sided dice and getting a sum greater than nine is $\frac{1}{6}$.
10. The chance that a randomly selected person in the United States is between 15 and 24 years old is about 14%. (Source: U.S. Census Bureau)

In Exercises 11 and 12, the table shows the approximate U.S. age distribution for the year 2005. Use the table to determine the probability of the event. (Source: U.S. Census Bureau)

Age	19 and under	20–34	35–59	60–84	85 and over
Population	28%	20%	35%	15%	2%

11. What is the probability that a randomly selected person in the United States will be at least 20 years old?
12. What is the probability that a randomly selected person in the United States will be less than 60 years old?



Chapter Quiz 167

3 Chapter Quiz

Take this quiz as you would take a quiz in class. After you are done, check your work against the answers given in the back of the book.

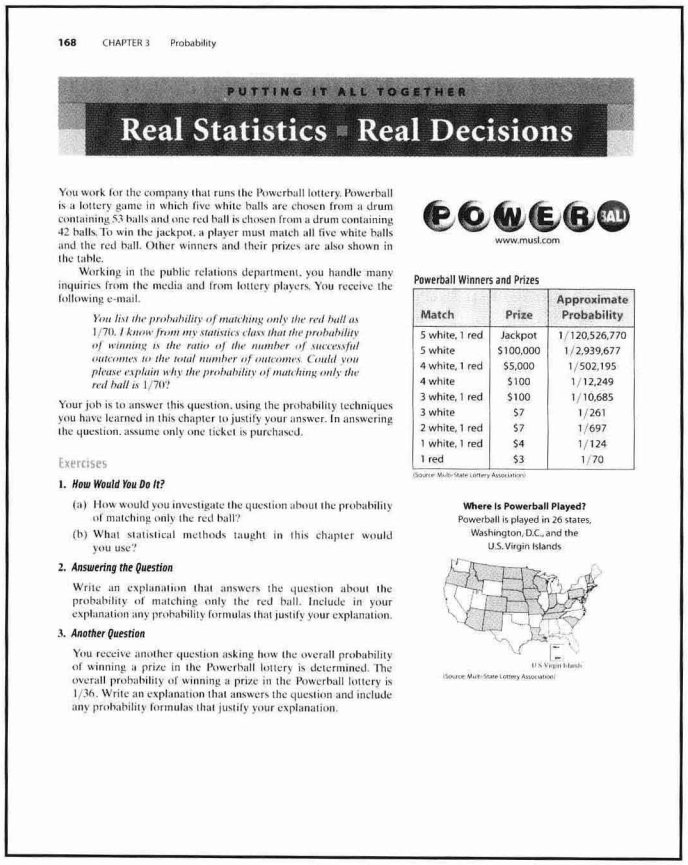
1. The table shows the estimated number (in thousands) of earned degrees conferred in the United States in the year 2004 by level and gender. (Source: National Center for Education Statistics)

		Gender		
		Male	Female	Total
Level of Degree	Associate	231	401	632
	Bachelor's	553	769	1322
	Master's	197	270	467
	Doctorate	25	20	45
	Total	1006	1460	2466

A person who earned a degree in the year 2004 is randomly selected. Find the probability of selecting someone who

(a) earned a bachelor's degree.
(b) earned a bachelor's degree given that the person is a female.
(c) earned a bachelor's degree given that the person is not a female.
(d) earned an associate degree or a bachelor's degree.
(e) earned a doctorate given that the person is a male.
(f) earned a master's degree or is a female.
(g) earned an associate degree and is a male.
(h) is a female given that the person earned a bachelor's degree.

2. Decide if the events are mutually exclusive. Then decide if the events are independent or dependent. Explain your reasoning.
   Event *A:* A golfer scoring the best round in a four-round tournament
   Event *B:* Losing the golf tournament
3. A shipment of 150 television sets contains three defective units. Determine how many ways a vending company can buy three of these units and receive (a) no defective units, (b) all defective units, and (c) at least one good unit.
4. In Exercise 3, find the probability of the vending company receiving (a) no defective units, (b) all defective units, and (c) at least one good unit.
5. The access code for a car's security system consists of four digits. The first digit cannot be 0 and the last digit must be even. How many different codes are available?
6. From a pool of 25 candidates, the offices of president, vice-president, secretary, and treasurer will be filled. In how many different ways can the offices be filled?



168 CHAPTER 3 Probability

PUTTING IT ALL TOGETHER

Real Statistics ▪ Real Decisions

You work for the company that runs the Powerball lottery. Powerball is a lottery game in which five white balls are chosen from a drum containing 53 balls and one red ball is chosen from a drum containing 42 balls. To win the jackpot, a player must match all five white balls and the red ball. Other winners and their prizes are also shown in the table.

Working in the public relations department, you handle many inquiries from the media and from lottery players. You receive the following e-mail.

> *You list the probability of matching only the red ball as 1/70. I know from my statistics class that the probability of winning is the ratio of the number of successful outcomes to the total number of outcomes. Could you please explain why the probability of matching only the red ball is 1/70?*

Your job is to answer this question, using the probability techniques you have learned in this chapter to justify your answer. In answering the question, assume only one ticket is purchased.

POWERBALL
www.musl.com

Powerball Winners and Prizes

Match	Prize	Approximate Probability
5 white, 1 red	Jackpot	1/120,526,770
5 white	$100,000	1/2,939,677
4 white, 1 red	$5,000	1/502,195
4 white	$100	1/12,249
3 white, 1 red	$100	1/10,685
3 white	$7	1/261
2 white, 1 red	$7	1/697
1 white, 1 red	$4	1/124
1 red	$3	1/70

(Source: Multi-State Lottery Association)

Where Is Powerball Played?
Powerball is played in 26 states, Washington, D.C., and the U.S. Virgin Islands

U.S. Virgin Islands

(Source: Multi-State Lottery Association)

Exercises

1. *How Would You Do It?*

(a) How would you investigate the question about the probability of matching only the red ball?

(b) What statistical methods taught in this chapter would you use?

2. *Answering the Question*

Write an explanation that answers the question about the probability of matching only the red ball. Include in your explanation any probability formulas that justify your explanation.

3. *Another Question*

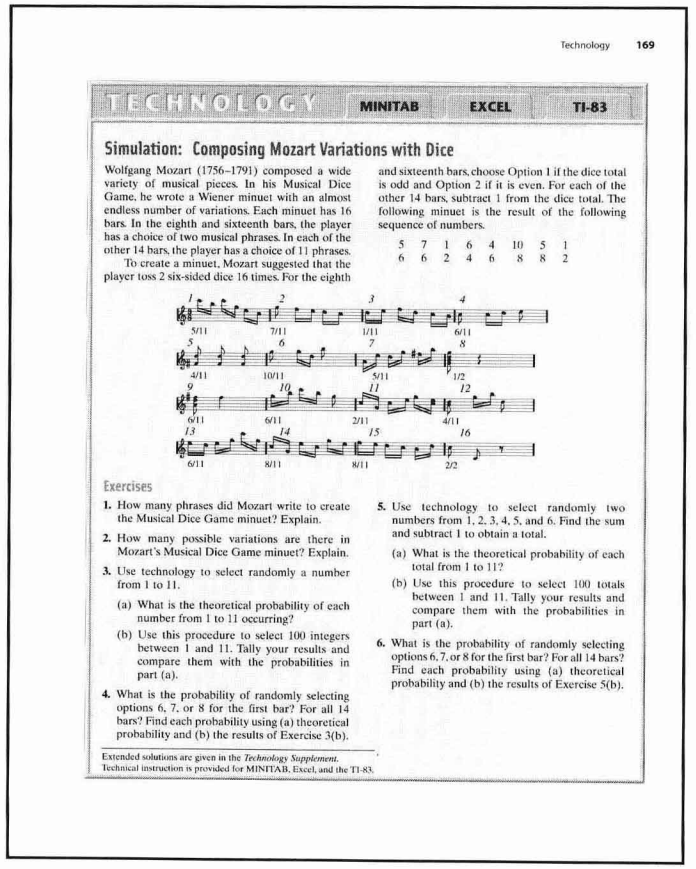
You receive another question asking how the overall probability of winning a prize in the Powerball lottery is determined. The overall probability of winning a prize in the Powerball lottery is 1/36. Write an explanation that answers the question and include any probability formulas that justify your explanation.

Real Statistics–Real Decisions

This feature encourages students to think critically and make informed decisions about real-world data. Exercises guide students from interpretation to drawing conclusions.

Chapter Technology Project

Each chapter has a full-page Technology project using tools from MINITAB, Excel, and TI-83 that gives students additional insight into the way technology is used to handle large data sets or complex, real-life questions.



Technology 169

TECHNOLOGY MINITAB EXCEL TI-83

Simulation: Composing Mozart Variations with Dice

Wolfgang Mozart (1756–1791) composed a wide variety of musical pieces. In his Musical Dice Game, he wrote a Wiener minuet with an almost endless number of variations. Each minuet has 16 bars. In the eighth and sixteenth bars, the player has a choice of two musical phrases. In each of the other 14 bars, the player has a choice of 11 phrases.

To create a minuet, Mozart suggested that the player toss 2 six-sided dice 16 times. For the eighth and sixteenth bars, choose Option 1 if the dice total is odd and Option 2 if it is even. For each of the other 14 bars, subtract 1 from the dice total. The following minuet is the result of the following sequence of numbers.

5	7	1	6	4	10	5	1
6	6	2	4	6	8	8	2

Exercises

1. How many phrases did Mozart write to create the Musical Dice Game minuet? Explain.
2. How many possible variations are there in Mozart's Musical Dice Game minuet? Explain.
3. Use technology to select randomly a number from 1 to 11.
   (a) What is the theoretical probability of each number from 1 to 11 occurring?
   (b) Use this procedure to select 100 integers between 1 and 11. Tally your results and compare them with the probabilities in part (a).
4. What is the probability of randomly selecting options 6, 7, or 8 for the first bar? For all 14 bars? Find each probability using (a) theoretical probability and (b) the results of Exercise 3(b).
5. Use technology to select randomly two numbers from 1, 2, 3, 4, 5, and 6. Find the sum and subtract 1 to obtain a total.
   (a) What is the theoretical probability of each total from 1 to 11?
   (b) Use this procedure to select 100 totals between 1 and 11. Tally your results and compare them with the probabilities in part (a).
6. What is the probability of randomly selecting options 6, 7, or 8 for the first bar? For all 14 bars? Find each probability using (a) theoretical probability and (b) the results of Exercise 5(b).

Extended solutions are given in the *Technology Supplement*.
Technical instruction is provided for MINITAB, Excel, and the TI-83.

How to Study Statistics

Study Strategies

Congratulations! You are about to begin your study of statistics. As you progress through the course, you should discover how to use statistics in your everyday life and in your career. The prerequisites for this course are two years of algebra, an open mind, and a willingness to study. When you are studying statistics, the material you learn each day builds on material you learned previously. There are no shortcuts—you must keep up with your studies every day. Before you begin, read through the following hints that will help you succeed.

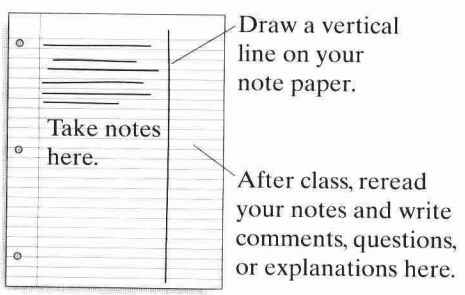
Making a Plan Make your own course plan right now! A good rule of thumb is to study at least two hours for every hour in class. After your first major exam, you will know if your efforts were sufficient. If you did not get the grade you wanted, then you should increase your study time, improve your study efficiency, or both.

Preparing for Class Before every class, review your notes from the previous class and read the portion of the text that is to be covered. Pay special attention to the definitions and rules that are highlighted. Read the examples and work through the Try It Yourself exercises that accompany each example. These steps take self-discipline, but they pay off because you will benefit much more from your instructor's presentation.

Attending Class Attend every class. Arrive on time with your text, materials for taking notes, and your calculator. If you must miss a class, get the notes from another student, go to a tutor or your instructor for help, or view the appropriate CD Lecture Video. Try to learn the material that was covered in the missed class before attending the next class.

Participating in Class When reading the text before class, reviewing your notes from a previous class, or working on your homework, write down any questions you have about the material. Ask your instructor these questions during class. Doing so will help you (and others in your class) understand the material better.

Taking Notes During class, be sure to take notes on definitions, examples, concepts, and rules. Focus on the instructor's cues to identify important material. Then, as soon after class as possible, review your notes and add any explanations that will help to make your notes more understandable to you.



(continued on next page)

Doing the Homework Learning statistics is like learning to play the piano or basketball. You cannot develop skills just by watching someone do it; you must do it yourself. The best time to do your homework is right after class, when the concepts are still fresh in your mind. Doing homework at this time increases your chances of retaining the information in long-term memory.

Finding a Study Partner When you get stuck on a problem, you may find that it helps to work with a partner. Even if you feel you are giving more help than you are getting, you will find that teaching others is an excellent way to learn.

Keeping Up with the Work Don't let yourself fall behind in this course. If you are having trouble, seek help immediately—from your instructor, a statistics tutor, your study partner, or additional study aids such as videotapes and software tutorials. Remember: If you have trouble with one section of your statistics text, there's a good chance that you will have trouble with later sections unless you take steps to improve your understanding.

Getting Stuck Every statistics student has had this experience: You work a problem and cannot solve it, or the answer you get does not agree with the one given in the text. When this happens, consider asking for help or taking a break to clear your thoughts. You might even want to sleep on it, or rework the problem, or reread the section in the text. Avoid getting frustrated or spending too much time on a single problem.

Preparing for Tests Cramming for a statistics test seldom works. If you keep up with the work and follow the suggestions given here, you should be almost ready for the test. To prepare for the chapter test, review the Chapter Summary and work the Review Exercises. Then set aside some time to take the sample Chapter Quiz. Analyze the results of your Chapter Quiz to locate and correct test-taking errors.

Taking a Test Most instructors do not recommend studying right up to the minute the test begins. Doing so tends to make people anxious. The best cure for test-taking anxiety is to prepare well in advance. Once the test begins, read the directions carefully and work at a reasonable pace. (You might want to read the entire test first, then work the problems in the order in which you feel most comfortable.) Don't rush! People who hurry tend to make careless errors. If you finish early, take a few moments to clear your thoughts and then go over your work.

Learning from Mistakes After your test is returned to you, go over any errors you might have made. Doing so will help you avoid repeating some systematic or conceptual errors. Don't dismiss any error as just a "dumb mistake." Take advantage of any mistakes by hunting for ways to improve your test-taking skills.