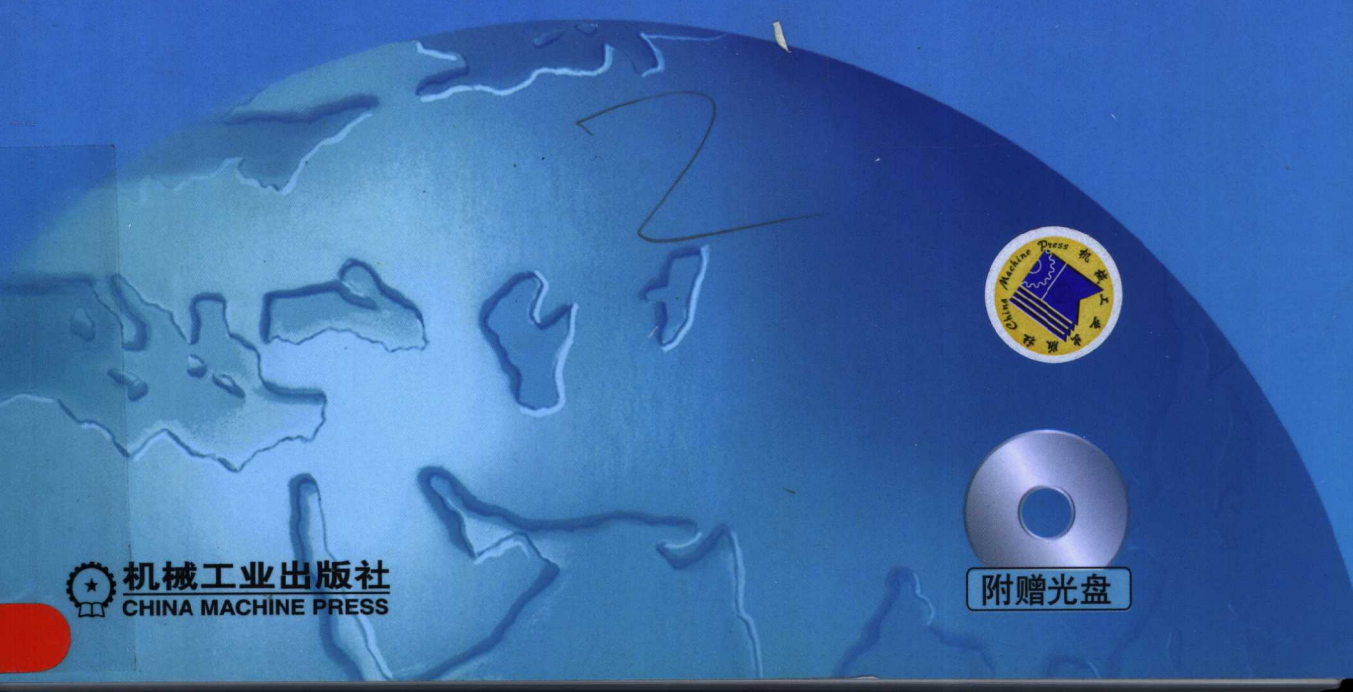
时代教育 · 国外高校优秀教材精选

（英文版·原书第11版）

概率与统计

Introduction to Probability and Statistics

William Mendenhall
（美）Robert J. Beaver 著
Barbara M.Beaver



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序

本书原版已经是第11版。该书系统地讲述了如何正确地收集数据资料，如何利用简单的统计软件MINITAB进行统计分析，以及如何从中得到有意义的统计结论。书中从各应用层面和案例分析进行论述，在使用尽量少的概率知识的前提下，介绍了应用统计的基本内容。

该书内容包括：数据的图形描述与数字描述，二维数据的描述，概率与分布函数，离散分布，正态分布，样本分布，大样本估计，小样本推断，方差分析，线性回归和相关，多变量回归分析，类别数据分析，非线性统计。

本书通俗易懂，无需微积分基础即可通览全书。

本书在编写上有以下的特色：

1）着重形象思维与直观判断，多用图形表示来浅显地引进各种统计概念。

2）层次分明，每段都有主要的概念与公式的小结和大量的练习题，各个领域的应用使用了不同的图标，便于读者复习总结。各章都有光盘数据的案例，有利于做“实战练习”。

3）以“几乎傻瓜式”的统计软件MINITAB带动统计计算，可以在台式电脑上进行，使用方便。也无需花费较多的时间学习Matlab、SAS、S-Plus等普适软件。通过使用MINITAB学会作统计分析，解除了手工计算的繁琐与枯燥。

本书适用于作为人文科学、经济管理等类专业本科生、研究生统计学教材，以及相关工作人员的参考书。

龚光鲁

于清华大学

出 版 说 明

随着我国加入 WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部近来出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社陆续推出了一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出了许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关。同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，举办原版教材的教师培训，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

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Preface

Every time you pick up a newspaper or a magazine, when you watch TV or surf the internet, you encounter statistics. Every time you fill out a questionnaire, register at an online website, or pass your grocery rewards card through an electronic scanner, your personal information becomes part of a database containing your personal statistical information. You cannot avoid the fact that in this information age, data collection and analysis are an integral part of our day-to-day activities. In order to be an educated consumer and citizen, you need to understand how statistics are used and misused in our daily lives.

The Secret to Our Success

The first college course in introductory statistics that we ever took used *Introduction to Probability and Statistics* by William Mendenhall. Since that time, this text, currently in the eleventh edition, has helped several generations of students understand what statistics is all about, and how it can be used as a tool in their particular area of application. The secret to the success of *Introduction to Probability and Statistics* is in its ability to blend the old with the new. With each revision, we try to build on the strong points of previous editions, while always looking for new ways to motivate, encourage, and interest students using new technological tools.

Hallmark Features of the Eleventh Edition

The eleventh edition retains the traditional outline for the coverage of descriptive and inferential statistics. In fact, in this revision, we have made a purposeful decision to maintain the straightforward presentation of the tenth edition. In the spirit of the tenth edition, we have continued to simplify and clarify the language, and to make the language and style more readable and "user friendly"—without sacrificing the statistical integrity of the presentation. Great effort has been taken to explain not only how to apply statistical procedures, but also to explain

- how to meaningfully describe real sets of data
- what the results of statistical tests mean in terms of their practical applications
- how to evaluate the validity of the assumptions behind statistical tests
- what to do when statistical assumptions have been violated

Exercises

In the tradition of all previous editions, the variety and number of real applications in the exercise sets is a major strength of this edition. We have revised the exercise sets to provide new and interesting real-world situations and real data sets, many of which are drawn from current periodicals and journals. The eleventh edition contains over 1000 exercises, many of which are new. Any exercises from previous editions that have been deleted will be available to the instructor as *Classic Exercises* on the Instructor's Suite CD and on a text-specific website. Exercises are graduated in level of difficulty; some, involving only basic techniques, can be solved by almost all students, while others, involving practical applications and interpretation of results, will challenge students to use more sophisticated statistical reasoning and understanding.

Organization and Coverage

Chapters 1–3 present descriptive data analysis for both one and two variables, using state-of-the-art *MINITAB* graphics. We believe that Chapters 1 through 10—with the possible exception of Chapter 3—should be covered in the order presented. The remaining chapters can be covered in any order. The analysis of variance chapter precedes the regression chapter, so that the instructor can present the analysis of variance as part of a regression analysis. Thus, the most effective presentation would order these three chapters as well.

Chapter 4 includes a full presentation of probability and probability distributions. Three optional sections—Counting Rules, the Total Law of Probability, and Bayes' Rule—are placed into the general flow of the text, and instructors will have the option of complete or partial coverage. The two sections that present event relations, independence and conditional probability, and the Additive and Multiplicative Rules have been rewritten in an attempt to clarify concepts that often are difficult for students to grasp. As in the tenth edition, the chapters on analysis of variance and linear regression include both calculational formulas and computer printouts in the basic text presentation. These chapters can now be used with equal ease by instructors who wish to use the "hands-on" computational approach to linear regression and ANOVA and by those who choose to focus on the interpretation of computer-generated statistical printouts.

One important change implemented in the tenth and eleventh editions involves the emphasis on p-values and their use in judging statistical significance. With the advent of computer-generated p-values, these probabilities have become essential components in reporting the results of a statistical analysis. As such, the observed value of the test statistic and its p-value are presented together at the outset of our discussion of statistical hypothesis testing as equivalent tools for decision-making. Statistical significance is defined in terms of preassigned values of α, and the *p-value approach* is presented as an alternative to the *critical value approach* for testing a statistical hypothesis. Examples are presented using both the *p-value* and *critical value* approaches to hypothesis testing. Discussion of the practical interpretation of statistical results, along with the difference between statistical significance and practical significance, is emphasized in the practical examples in the text.

Do It Yourself!—New to the Eleventh Edition

Easy access to the internet has made it possible for students to visualize statistical concepts using an interactive webtool called an **applet.** These applets were written by Gary McClelland, author of *Seeing Statistics*™, and have been customized specifically to match the presentation and notation used in this edition. Found on the CD-ROM that accompanies the text and accessed using a browser such as Internet Explorer or

Netscape Navigator, they provide visual reinforcement of the concepts presented in the text. Applets allow the user to perform a statistical experiment, to interact with a statistical graph to change its form, or to access an interactive "statistical table." At appropriate points in the text, a screen capture of each applet is displayed and explained, and each student is encouraged to "Do It Yourself" using newly written exercises at the end of each chapter. We are excited to see these applets integrated into statistical pedagogy and hope that you will take advantage of their visual appeal to your students.

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DO IT YOURSELF!

Example 7.4 can be solved using the **Normal Probabilities for Means** applet. If you enter the values for $\bar{x}$, σ, μ, and n (press "Enter" to record each change) and adjust the dropdown list at the bottom of the applet, you can calculate a tail area, a cumulative area, or the area between $-z_0$ and z_0. Conversely, if you need to find the value of $\bar{x}$ that cuts off a certain area under the curve, enter the area in the box marked "prob:" at the bottom of the applet, and the applet will provide the value of $\bar{x}$. The applet in Figure 7.10 is set to calculate $P(7 < \bar{x} < 9) = .829$, correct to three decimal places. You will use this applet for the *Do It Yourself Exercises* at the end of the chapter.

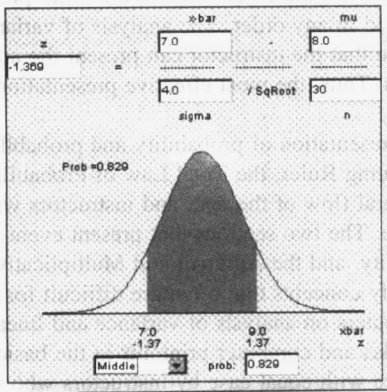


FIGURE 7.10 **Normal Probabilities for Means** applet

***Do It Yourself!* text and exercises from pages 250 and 271.**

Exercises DO IT YOURSELF!

7.66 Refer to the die-tossing experiment with $n = 1$ in Section 7.4 in which x is the number on the upper face of a single balanced die.

a. Use the formulas in Section 4.8 to verify that $\mu = 3.5$ and $\sigma = 1.71$ for this population.

b. Use the **Central Limit Theorem** applet to toss a single die at least 2000 times. (Your simulation can be done quickly by using the Roll 100 Sets button.) What are the mean and standard deviation of these 2000 observations? What is the shape of the histogram?

c. Compare the results of part b to the actual probability distribution shown in Figure 7.3 and the actual mean and standard deviation in part a. They should be similar!

7.67 Two balanced dice are thrown, and the average number on the two upper faces is recorded.

a. Use the values $\mu = 3.5$ and $\sigma = 1.71$ from Exercise 7.66. What are the theoretical mean and standard deviation of the sampling distribution for $\bar{x}$?

b. Use the **Central Limit Theorem** applet to toss a single die at least 2000 times. (Your simulation can be done quickly by using the Roll 100 Sets button.) What are the mean and standard deviation of these 2000 observations? What is the shape of the histogram?

c. Compare the results of part b to the actual probability distribution shown in Figure 7.4 and the actual mean and standard deviation in part a.

7.68 Repeat the instructions in Exercise 7.67 when three dice are tossed.

7.69 Repeat the instructions in Exercise 7.67 when four dice are tossed.

7.70 Suppose a random sample of $n = 5$ observations is selected from a population that is normally distributed, with mean equal to 1 and standard deviation equal to .36.

a. Give the mean and the standard deviation of the sampling distribution of $\bar{x}$.

b. Find the probability that $\bar{x}$ exceeds 1.3, using the **Normal Probabilities for Means** applet.

c. Find the probability that the sample mean $\bar{x}$ is less than .5.

d. Find the probability that the sample mean deviates from the population mean $\mu = 1$ by more than .4.

Other Features New to the Eleventh Edition

- **Graphical and numerical data description includes both traditional and EDA methods, using computer graphics generated by *MINITAB 13* for Windows.**

Graphical and numerical data description using computer graphics generated by *MINITAB 13* from page 25.

EXAMPLE 1.11 Twenty-five households are polled in a marketing survey, and Table 1.11 lists the numbers of quarts of milk purchased during a particular week. Construct a relative frequency histogram to describe the data.

TABLE 1.11 Quarts of milk purchased by 25 households

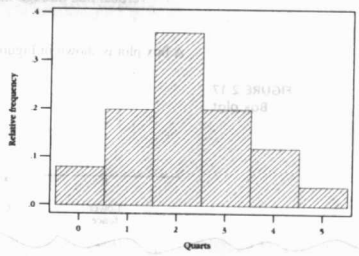
0	3	5	4	3
2	1	3	1	2
1	1	2	0	1
4	3	2	2	2
2	2	2	3	4

Solution The variable being measured is "number of quarts of milk," which is a discrete variable that takes on only integer values. In this case, it is simplest to choose the classes or subintervals as the integer values over the range of observed values: 0, 1, 2, 3, 4, and 5. Table 1.12 shows the classes and their corresponding frequencies and relative frequencies. The relative frequency histogram, generated using *MINITAB*, is shown in Figure 1.16.

TABLE 1.12 Frequency table for Example 1.11

Number of Quarts	Frequency	Relative Frequency
0	2	.08
1	5	.20
2	9	.36
3	5	.20
4	3	.12
5	1	.04

FIGURE 1.16 Minitab histogram for Example 1.11



- Presentation of the box plot is now preceded by the introduction of the five-number summary. The box plot has been simplified to include only one lower and upper fence for detecting outliers. This is in keeping with the procedure now implemented in *MINITAB 13*.

The five-number summary and box plot descriptions from page 77.

The five-number summary consists of the smallest number, the lower quartile, the median, the upper quartile and the largest number, presented in order from smallest to largest:

Min Q_1 Median Q_3 Max

By definition, one-fourth of the measurements in the data set lie between each of the four adjacent pairs of numbers.

The five-number summary can be used to create a simple graph called a **box plot** to visually describe the data distribution. From the box plot, you can quickly detect any skewness in the shape of the distribution and see whether there are any outliers in the data set.

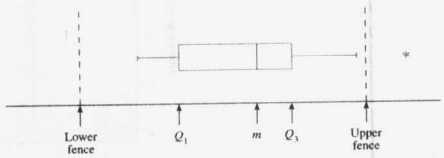
An outlier may result from transposing digits when recording a measurement, from incorrectly reading an instrument dial, from a malfunctioning piece of equipment, and from other problems. Even when there are no recording or observational errors, a data set may contain one or more valid measurements that, for one reason or another, differ markedly from the others in the set. These outliers can cause a marked distortion in commonly used numerical measures such as $\bar{x}$ and s. In fact, outliers may themselves contain important information not shared with the other measurements in the set. Therefore, isolating outliers, if they are present, is an important step in any preliminary analysis of a data set. The box plot is designed expressly for this purpose.

To Construct a Box Plot

- Calculate the median, the upper and lower quartiles, and the IQR for the data set.
- Draw a horizontal line representing the scale of measurement. Form a box just above the horizontal line with the right and left ends at Q_1 and Q_3. Draw a vertical line through the box at the location of the median.

A box plot is shown in Figure 2.17.

FIGURE 2.17
Box plot



- The presentation in Chapter 4 has been rearranged and rewritten to clarify the concepts of event relations, independence and conditional probabilities, and the Additive and Multiplicative Rules of Probability.
- The table of standard normal curve areas (Table 3 in Appendix I) has been changed to show cumulative probabilities—that is, $P(z \leq z_0)$. The table gives cumulative probabilities, correct to four decimal places, for values of z from -3.49 to 3.49. This change makes the table consistent with the format of the binomial and Poisson tables, and should be easier for students to use.
- All examples and exercises in the text contain new printouts based on *MINITAB 13*. *MINITAB* printouts are provided for some exercises, while other exercises require the student to obtain solutions without using the computer.

Small-Sample Testing and Estimation

The tests and confidence intervals for population means based on the Student's t distribution are found in a *MINITAB* submenu by choosing **Stat → Basic Statistics.** You will see choices for **1-Sample t, 2-Sample t,** and **Paired t,** which will generate Dialog boxes for the procedures in Sections 10.3, 10.4, and 10.5, respectively. You must choose the columns in which the data are stored and the null and alternative hypotheses to be tested (or the confidence coefficient for a confidence interval). In the case of the two-sample t test, you must indicate whether the population variances are assumed equal or unequal, so that *MINITAB* can perform the correct test. We will display some of the Dialog boxes and Session window outputs for the examples in this chapter, beginning with the one-sample t test of Example 10.3.

First, enter the six recorded weights—.46, .61, .52, .48, .57, .54—in column C1 and name the

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An *About MINITAB* section from pages 411–413.

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FIGURE 10.22

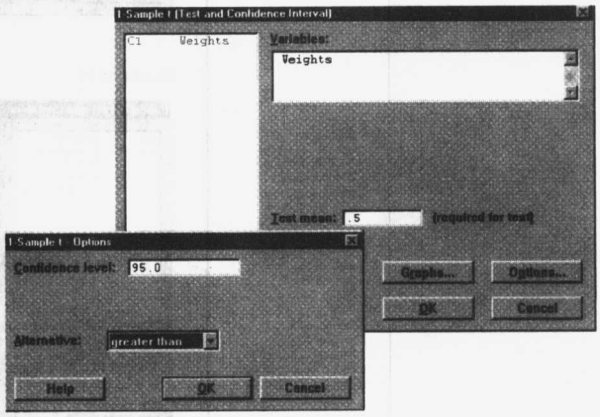
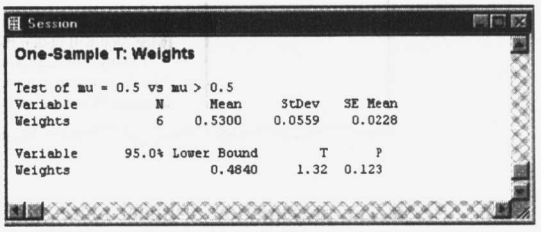


FIGURE 10.23



Use the second method and enter the data from Example 10.5 into columns C2 and C3. Then use **Stat → Basic Statistics → 2-Sample t** to generate the Dialog box in Figure 10.24. Check "Samples in different columns," selecting C2 and C3 from the box on the left. Select the proper alternative hypothesis in the Options box, and check the "Assume equal variances" box. (Otherwise, *MINITAB* will perform Satterthwaite's approximation for unequal variances.) The two-sample output when you click **OK** twice automatically contains a 95% one- or two-sided confidence interval as well as the test statistic and p-value (you can change the confidence coefficient if you like). The output for Example 10.5 is shown in Figure 10.13 on page 382.

For a paired-difference test, the two samples are entered into separate columns, which we did with the tire wear data in Table 10.3. Use **Stat → Basic Statistics → Paired t** to generate the Dialog box in Figure 10.25. Select C4 and C5 from the box on the left, and use **Options** to pick the proper alternative hypothesis. You may change the

MINITAB

FIGURE 10.24

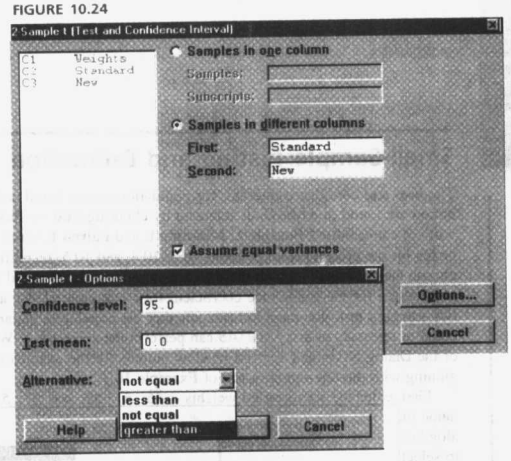
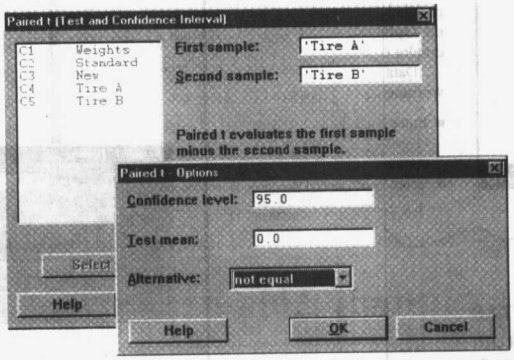


FIGURE 10.25



confidence coefficient or the test value (the default value is zero). When you click **OK** twice, you will obtain the output shown in Figure 10.15 on page 390.

Finally, although you cannot use *MINITAB* to perform either the χ^2 or the F test in this chapter, you can use **Calc → Probability Distributions → Chi-square (or F)**, selecting "Cumulative probability" to calculate the appropriate p-value.

- The presentation of linear regression in Chapter 12 has been rearranged and rewritten, so that the discussion of diagnostic tests and residual plots precedes the section on estimation and testing.

The Role of the Computer in the Eleventh Edition

Computers are now a common tool for college students in all disciplines. Most students are accomplished users of word-processors, spreadsheets, and databases, and they have no trouble navigating through software packages in the Windows environment. We believe, however, that advances in computer technology should not turn statistical analyses into a "black box." Rather, we choose to use the computational shortcuts and

interactive visual tools that modern technology provides to give us more time to emphasize statistical reasoning as well as the understanding and interpretation of statistical results.

In this edition, students will be able to use the computer both for standard statistical analyses and as a tool for reinforcing and visualizing statistical concepts. *MINITAB 13* for Windows is used exclusively as the computer package for statistical analysis. Almost all graphs and figures, as well as all computer printout, are generated using this version of *MINITAB*. However, we have chosen to isolate the instructions for generating this output into individual sections called "About *MINITAB*" at the end of each chapter. Each discussion used numerical examples to guide the student through the *MINITAB* commands and options necessary for the procedures presented in that chapter. We have included references to visual screen captures from *MINITAB 13*, so that the student can actually work through these sections as "mini-labs."

If you do not need "hands-on" knowledge of *MINITAB*, or if you are using another software package, you may choose to skip these sections and simply use the *MINITAB* printouts as guides for the basic understanding of computer printouts.

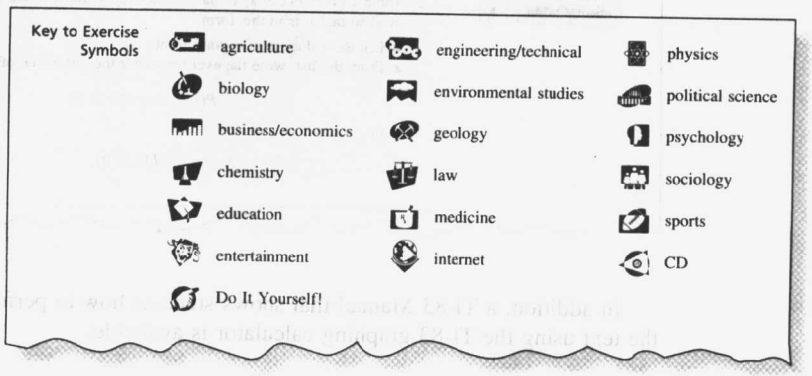
Any student who has access to a computer with a browser such as Internet Explorer or Netscape Navigator can use the applets found on the CD-ROM that accompanies the text to visualize a variety of statistical concepts. In addition, some of the applets can be used instead of computer software to perform simple statistical analyses. Exercises written specifically for use with these applets appear in a section at the end of each chapter. Students can use the applets at home or in a computer lab. They can use them as they read through the text material, once they have finished reading the entire chapter, or as a tool for exam review. Instructors can assign applet exercises to the students, use the applets as a tool in a lab setting, or use them for visual demonstrations during lectures. We believe that these applets will be a powerful tool that will increase student enthusiasm for, and understanding of, statistical concepts and procedures.

Study Aids

The many and varied exercises in the text provide the best learning tool for students embarking on a first course in statistics. An exercise number printed in color indicates that a detailed solution appears in the *Study Guide and Student Solutions Manual*, which is available as a supplement for students.

Icons to the left of the exercise numbers are used to identify areas of application such as quality control, engineering, education, social sciences, biological sciences, psychology, entertainment, and so on. The coding used to indicate the area of application is shown below and is also reproduced on the inside left of the back cover.

Icons used in the exercise sections to identify applications.



The CD-ROM that accompanies each new copy of the text provides students with an array of study resources, including the complete set of *Do It Yourself!* applets, data sets for many of the text exercises saved in a variety of formats, and a set of interactive tutorial files. Students will also have access to a section of the text-specific website containing PowerPoint slides, the data sets and a set of web quizzes.

Sections called *Key Concepts and Formulas* appear in each chapter as a review in outline form of the material covered in that chapter.

Key Concepts and Formulas from page 410.

Key Concepts and Formulas

I. **Experimental Designs for Small Samples**

1. **Single random sample:** The sampled population must be normal.
2. **Two independent random samples:** Both sampled populations must be normal.
   a. Populations have a common variance σ^2.
   b. Populations have different variances: σ_1^2 and σ_2^2.
3. **Paired-difference** or **matched pairs** design: The samples are not independent.

II. **Statistical Tests of Significance**

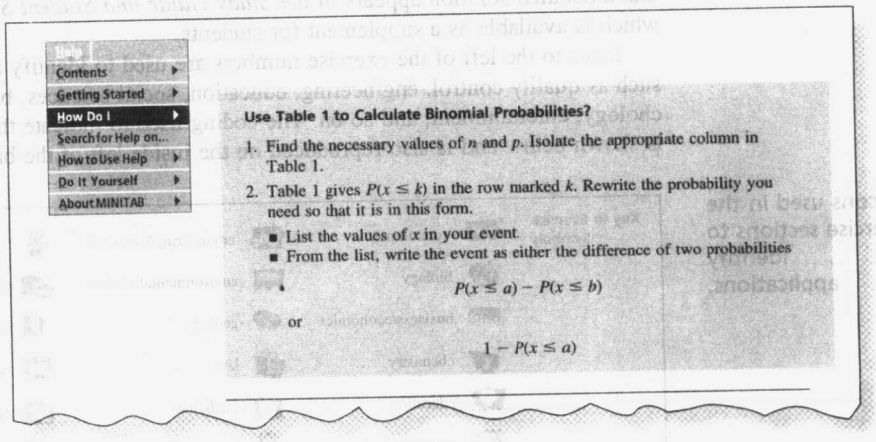
1. Based on the t, F, and χ^2 distributions
2. Use the same procedure as in Chapter 9
3. **Rejection region—critical values** and **significance levels:** based on the t, F, or χ^2 distributions with the appropriate degrees of freedom
4. **Tests of population parameters:** a single mean, the difference between two means, a single variance, and the ratio of two variances

III. **Small-Sample Test Statistics**

To test one of the population parameters when the sample sizes are small, use the following test statistics:

The *Do It Yourself!* sections appear within the body of the text, explaining the use of a particular Java applet. Boxed and shaded definitions are again included, along with step-by-step hints for problem solving in displays called *How Do I . . . ?*

How Do I display from page 180.



In addition, a TI-83 Manual that shows students how to perform the techniques in the text using the TI-83 graphing calculator is available.

Instructor Resources

The Instructor's Suite CD supplied to adopters of the eleventh edition contains a variety of teaching aids, including:

- The Complete Solutions Manual in pdf format
- Test bank files in Microsoft Word
- Animated PowerPoint presentations
- The complete set of Do It Yourself! applets
- Data sets in a variety of formats

The PowerPoint presentations and data sets will also be available in the instructor's section of a text-specific website. The website will also contain the *Classic Exercises* with solutions in pdf format, and three real data sets, along with *Exercises using the Large Data Sets,* which can be used throughout the course. A file named "Fortune" contains the revenues (in millions) for the *Fortune* 500 largest U.S. industrial corporations in 2002; a file named "Batting" contains the batting averages for the National and American baseball league batting champions from 1876 to 2001; and a file named "BldPress" contains the age and diastolic and systolic blood pressures for 965 men and 945 women compiled by the National Institutes of Health.

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