Example 8.2 illustrates the effect of using a 99% confidence interval.

EXAMPLE 8.2

Estimating the Mean Paper Length with 99% Confidence

Construct a 99% confidence interval estimate for the population mean paper length.

SOLUTION Using Equation (8.1) on page 276, with $Z_{\alpha/2} = 2.58$ for 99% confidence,

$$\bar{X} \pm Z_{\alpha/2}\frac{\sigma}{\sqrt{n}} = 10.998 \pm (2.58)\frac{0.02}{\sqrt{100}}$$
$$= 10.998 \pm 0.00516$$
$$10.9928 \le \mu \le 11.0032$$

Once again, because 11 is included within this wider interval, you have no reason to believe that anything is wrong with the production process.

As discussed in Section 7.2, the sampling distribution of the sample mean, $\bar{X}$, is normally distributed if the population for your characteristic of interest, X, follows a normal distribution. And if the population of X does not follow a normal distribution, the Central Limit Theorem almost always ensures that $\bar{X}$ is approximately normally distributed when n is large. However, when dealing with a small sample size and a population that does not follow a normal distribution, the sampling distribution of $\bar{X}$ is not normally distributed, and therefore the confidence interval discussed in this section is inappropriate. In practice, however, as long as the sample size is large enough and the population is not very skewed, you can use the confidence interval defined in Equation (8.1) to estimate the population mean when σ is known. To assess the assumption of normality, you can evaluate the shape of the sample data by constructing a histogram, stem-and-leaf display, boxplot, or normal probability plot.

Student Tip
Because understanding the confidence interval concept is very important when reading the rest of this book, review this section carefully to understand the underlying concept—even if you never have a practical reason to use the confidence interval estimate of the mean (σ known) method.

Can You Ever Know the Population Standard Deviation?

To solve Equation (8.1), you must know the value for σ, the population standard deviation. To know σ implies that you know all the values in the entire population. (How else would you know the value of this population parameter?) If you knew all the values in the entire population, you could directly compute the population mean. There would be no need to use the *inductive* reasoning of inferential statistics to *estimate* the population mean. In other words, if you know σ, you really do not have a need to use Equation (8.1) to construct a confidence interval estimate of the mean (σ known).

More significantly, in virtually all real-world business situations, you would never know the standard deviation of the population. In business situations, populations are often too large to examine all the values. So why study the confidence interval estimate of the mean (σ known) at all? This method serves as an important introduction to the concept of a confidence interval because it uses the normal distribution, which has already been thoroughly discussed in Chapters 6 and 7. In the next section, you will see that constructing a confidence interval estimate when σ is not known requires another distribution (the t distribution) not previously mentioned in this book.

Problems for Section 8.1

LEARNING THE BASICS

8.1 If $\bar{X} = 85$, $\sigma = 8$, and $n = 64$, construct a 95% confidence interval estimate for the population mean, μ.

8.2 If $\bar{X} = 125$, $\sigma = 24$, and $n = 36$, construct a 99% confidence interval estimate for the population mean, μ.

8.3 Why is it not possible in Example 8.1 on page 277 to have 100% confidence? Explain.

8.4 Is it true in Example 8.1 on page 277 that you do not know for sure whether the population mean is between 10.9941 and 11.0019 inches? Explain.

APPLYING THE CONCEPTS

8.5 A market researcher selects a simple random sample of $n = 100$ Twitter users from a population of over 100 million Twitter registered users. After analyzing the sample, she states that she has 95% confidence that the mean time spent on the site per day is between 15 and 57 minutes. Explain the meaning of this statement.

8.6 Suppose that you are going to collect a set of data, either from an entire population or from a random sample taken from that population.

a. Which statistical measure would you compute first: the mean or the standard deviation? Explain.

b. What does your answer to (a) tell you about the "practicality" of using the confidence interval estimate formula given in Equation (8.1)?

8.7 Consider the confidence interval estimate discussed in Problem 8.5. Suppose the population mean time spent on the site is 36 minutes a day. Is the confidence interval estimate stated in Problem 8.5 correct? Explain.

8.8 You are working as an assistant to the dean of institutional research at your university. The dean wants to survey members of the alumni association who obtained their baccalaureate degrees five years ago to learn what their starting salaries were in their first full-time job after receiving their degrees. A sample of 100 alumni is to be randomly selected from the list of 2,500 graduates in that class. If the dean's goal is to construct a 95% confidence interval estimate for the population mean starting salary, why is it not possible that you will be able to use Equation (8.1) on page 276 for this purpose? Explain.

8.9 A bottled water distributor wants to estimate the amount of water contained in 1-gallon bottles purchased from a nationally known water bottling company. The water bottling company's specifications state that the standard deviation of the amount of water is equal to 0.02 gallon. A random sample of 50 bottles is selected, and the sample mean amount of water per 1-gallon bottle is 0.995 gallon.

a. Construct a 99% confidence interval estimate for the population mean amount of water included in a 1-gallon bottle.

b. On the basis of these results, do you think that the distributor has a right to complain to the water bottling company? Why?

c. Must you assume that the population amount of water per bottle is normally distributed here? Explain.

d. Construct a 95% confidence interval estimate. How does this change your answer to (b)?

SELF Test **8.10** The operations manager at a compact fluorescent light bulb (CFL) factory needs to estimate the mean life of a large shipment of CFLs. The manufacturer's specifications are that the standard deviation is 1,000 hours. A random sample of 64 CFLs indicated a sample mean life of 7,500 hours.

a. Construct a 95% confidence interval estimate for the population mean life of compact fluorescent light bulbs in this shipment.

b. Do you think that the manufacturer has the right to state that the compact fluorescent light bulbs have a mean life of 8,000 hours? Explain.

c. Must you assume that the population compact fluorescent light bulb life is normally distributed? Explain.

d. Suppose that the standard deviation changes to 800 hours. What are your answers in (a) and (b)?

8.2 Confidence Interval Estimate for the Mean (σ Unknown)

In the previous section, you learned that in most business situations, you do not know σ, the population standard deviation. This section discusses a method of constructing a confidence interval estimate of μ that uses the sample statistic S as an estimate of the population parameter σ.

Student's *t* Distribution

At the start of the twentieth century, William S. Gosset was working at Guinness in Ireland, trying to help brew better beer less expensively (see reference 5). As he had only small samples to study, he needed to find a way to make inferences about means without having to know σ. Writing under the pen name "Student,"[1] Gosset solved this problem by developing what today is known as the **Student's *t* distribution**, or the *t* distribution.

If the random variable X is normally distributed, then the following statistic:

$$t = \frac{\overline{X} - \mu}{\dfrac{S}{\sqrt{n}}}$$

has a *t* distribution with $n - 1$ **degrees of freedom**. This expression has the same form as the Z statistic in Equation (7.4) on page 255, except that S is used to estimate the unknown σ.

[1]Guinness considered all research conducted to be proprietary and a trade secret. The firm prohibited its employees from publishing their results. Gosset circumvented this ban by using the pen name "Student" to publish his findings.

FIGURE 8.11

Confidence interval estimates of the mean for 20 samples of $n = 10$ randomly selected from the population of $N = 200$ orders with σ unknown

Sample	N	Mean	Std Dev	SE Mean	95% Conf. Int.
S01	10	71.64	7.58	2.40	(66.22, 77.06)
S02	10	67.22	10.95	3.46	(59.39, 75.05)
S03	10	67.97	14.83	4.69	(57.36, 78.58)
S04	10	73.90	10.59	3.35	(66.33, 81.47)
S05	10	67.11	11.12	3.52	(59.15, 75.07)
S06	10	68.12	10.83	3.43	(60.37, 75.87)
S07	10	65.80	10.85	3.43	(58.03, 73.57)
S08	10	77.58	11.04	3.49	(69.68, 85.48)
S09	10	66.69	11.45	3.62	(58.50, 74.88)
S10	10	62.55	8.58	2.71	(56.41, 68.69)
S11	10	71.12	12.82	4.05	(61.95, 80.29)
S12	10	70.55	10.52	3.33	(63.02, 78.08)
S13	10	65.51	8.16	2.58	(59.67, 71.35)
S14	10	64.90	7.55	2.39	(59.50, 70.30)
S15	10	66.22	11.21	3.54	(58.20, 74.24)
S16	10	70.43	10.21	3.23	(63.12, 77.74)
S17	10	72.04	6.25	1.96	(67.57, 76.51)
S18	10	73.91	11.29	3.57	(65.83, 81.99)
S19	10	71.49	9.76	3.09	(64.51, 78.47)
S20	10	70.15	10.84	3.43	(62.39, 77.91)

and the interval for sample 10 $(56.41 - 68.69)$ do not correctly estimate the population mean. All the other intervals correctly estimate the population mean. Once again, remember that in practice you select only one sample, and you are unable to know for sure whether your one sample provides a confidence interval that includes the population mean.

Problems for Section 8.2

LEARNING THE BASICS

8.11 If $\bar{X} = 75$, $S = 24$, and $n = 36$, and assuming that the population is normally distributed, construct a 95% confidence interval estimate for the population mean, μ.

8.12 Determine the critical value of t in each of the following circumstances:

a. $1 - \alpha = 0.95, n = 10$
b. $1 - \alpha = 0.99, n = 10$
c. $1 - \alpha = 0.95, n = 32$
d. $1 - \alpha = 0.95, n = 65$
e. $1 - \alpha = 0.90, n = 16$

8.13 Assuming that the population is normally distributed, construct a 95% confidence interval estimate for the population mean for each of the following samples:

Sample A: 1 1 1 1 8 8 8 8

Sample B: 1 2 3 4 5 6 7 8

Explain why these two samples produce different confidence intervals even though they have the same mean and range.

8.14 Assuming that the population is normally distributed, construct a 95% confidence interval for the population mean, based on the following sample of size $n = 7$:

1 2 3 4 5 6 20

Change the value of 20 to 7 and recalculate the confidence interval. Using these results, describe the effect of an outlier (i.e., an extreme value) on the confidence interval.

APPLYING THE CONCEPTS

8.15 A marketing researcher wants to estimate the mean savings ($) realized by shoppers who showroom. Showrooming is the practice of inspecting products in retail stores and then purchasing the products online at a lower price. A random sample of 100 shoppers who recently purchased a consumer electronics item online after making a visit to a retail store yielded a mean savings of $58 and a standard deviation of $55.

a. Construct a 95% confidence interval estimate for the mean savings for all showroomers who purchased a consumer electronics item.

b. Suppose the owners of a consumer electronics retailer wants to estimate the total value of lost sales attributed to the next 1,000 showroomers that enter their retail store. How are the results in (a) useful in assisting the consumer electronics retailer in their estimation?

SELF Test **8.16** A survey of nonprofit organizations showed that online fundraising has increased in the past year. Based on a random sample of 55 nonprofits, the mean one-time gift donation in the past year was $75, with a standard deviation of $9.

a. Construct a 95% confidence interval estimate for the population mean one-time gift donation.

b. Interpret the interval constructed in (a).

8.17 The U.S. Department of Transportation requires tire manufacturers to provide tire performance information on the sidewall of a tire to better inform prospective customers as they make purchasing decisions. One very important measure of tire performance is the tread wear index, which indicates the tire's resistance to tread wear compared with a tire graded with a base of 100. A tire with a grade of 200 should last twice as long, on average, as a tire graded with a base of 100. A consumer organization wants to estimate the actual tread wear index of a brand name of tires that claims "graded 200" on the sidewall of the tire. A random sample of $n = 18$ indicates a sample mean tread wear index of 195.3 and a sample standard deviation of 21.4.

a. Assuming that the population of tread wear indexes is normally distributed, construct a 95% confidence interval estimate for the population mean tread wear index for tires produced by this manufacturer under this brand name.

b. Do you think that the consumer organization should accuse the manufacturer of producing tires that do not meet the performance information provided on the sidewall of the tire? Explain.

c. Explain why an observed tread wear index of 210 for a particular tire is not unusual, even though it is outside the confidence interval developed in (a).

8.18 The file FastFood contains the amount that a sample of 15 customers spent for lunch ($) at a fast-food restaurant:

7.42 6.29 5.83 6.50 8.34 9.51 7.10 6.80 5.90
4.89 6.50 5.52 7.90 8.30 9.60

a. Construct a 95% confidence interval estimate for the population mean amount spent for lunch ($) at a fast-food restaurant, assuming a normal distribution.

b. Interpret the interval constructed in (a).

8.19 The file Sedans contains the overall miles per gallon (MPG) of 2013 midsized sedans:

38 26 30 26 25 27 22 27 39 24 24 26 25
23 25 26 31 26 37 22 29 25 33 21 21

Source: Data extracted from "Ratings," *Consumer Reports*, April 2013, pp. 30–31.

a. Construct a 95% confidence interval estimate for the population mean MPG of 2013 family sedans, assuming a normal distribution.

b. Interpret the interval constructed in (a).

c. Compare the results in (a) to those in Problem 8.20(a).

8.20 The file SUV contains the overall MPG of 2013 small SUVs:

22 23 21 22 25 26 22 22 21
19 22 22 26 23 24 21 22

Source: Data extracted from "Ratings," *Consumer Reports*, April 2013, pp. 34–35.

a. Construct a 95% confidence interval estimate for the population mean MPG of 2013 small SUVs, assuming a normal distribution.

b. Interpret the interval constructed in (a).

c. Compare the results in (a) to those in Problem 8.19(a).

8.21 Is there a difference in the yields of different types of investments? The file CDRate contains the yields for a one-year certificate of deposit (CD) and a five-year CD for 23 banks in the United States as of March 20, 2013. (Data extracted from **www.Bankrate.com**, March 20, 2013.)

a. Construct a 95% confidence interval estimate for the mean yield of one-year CDs.

b. Construct a 95% confidence interval estimate for the mean yield of five-year CDs.

c. Compare the results of (a) and (b).

8.22 One of the major measures of the quality of service provided by any organization is the speed with which the organization responds to customer complaints. A large family-held department store selling furniture and flooring, including carpet, had undergone a major expansion in the past several years. In particular, the flooring department had expanded from 2 installation crews to an installation supervisor, a measurer, and 15 installation crews. The store had the business objective of improving its response to complaints. The variable of interest was defined as the number of days between when the complaint was made and when it was resolved. Data were collected from 50 complaints that were made in the past year. The data, stored in Furniture, are as follows:

54 5 35 137 31 27 152 2 123 81 74 27
11 19 126 110 110 29 61 35 94 31 26 5
12 4 165 32 29 28 29 26 25 1 14 13
13 10 5 27 4 52 30 22 36 26 20 23
33 68

a. Construct a 95% confidence interval estimate for the population mean number of days between the receipt of a complaint and the resolution of the complaint.

b. What assumption must you make about the population distribution in order to construct the confidence interval estimate in (a)?

c. Do you think that the assumption needed in order to construct the confidence interval estimate in (a) is valid? Explain.

d. What effect might your conclusion in (c) have on the validity of the results in (a)?

8.23 A manufacturing company produces electric insulators. You define the variable of interest as the strength of the insulators. If the insulators break when in use, a short circuit is likely. To test the strength of the insulators, you carry out destructive testing to determine how much force is required to break the insulators. You measure force by observing how many pounds are applied to the insulator before it breaks. You collect the force data for 30 insulators selected for the experiment and organize and store these data in Force:

1,870 1,728 1,656 1,610 1,634 1,784 1,522 1,696
1,592 1,662 1,866 1,764 1,734 1,662 1,734 1,774
1,550 1,756 1,762 1,866 1,820 1,744 1,788 1,688
1,810 1,752 1,680 1,810 1,652 1,736

a. Construct a 95% confidence interval estimate for the population mean force.

b. What assumption must you make about the population distribution in order to construct the confidence interval estimate in (a)?

c. Do you think that the assumption needed in order to construct the confidence interval estimate in (a) is valid? Explain.

8.24 The file MarketPenetration contains Facebook penetration values (the percentage of a country's population that are Facebook users) for 15 countries:

52.56 33.09 5.37 19.41 32.52 41.69 51.61 30.12
39.07 30.62 38.16 49.35 27.13 53.45 40.01

Source: Data extracted from **www.socialbakers.com/facebook-statistics/**.

a. Construct a 95% confidence interval estimate for the population mean Facebook penetration.
b. What assumption do you need to make about the population to construct the interval in (a)?
c. Given the data presented, do you think the assumption needed in (a) is valid? Explain.

8.25 One operation of a mill is to cut pieces of steel into parts that are used in the frame for front seats in an automobile. The steel is cut with a diamond saw, and the resulting parts must be cut to be within ± 0.005 inch of the length specified by the automobile company. The measurement reported from a sample of 100 steel parts (stored in **Steel**) is the difference, in inches, between the actual length of the steel part, as measured by a laser measurement device, and the specified length of the steel part. For example, the first observation, -0.002, represents a steel part that is 0.002 inch shorter than the specified length.
a. Construct a 95% confidence interval estimate for the population mean difference between the actual length of the steel part and the specified length of the steel part.
b. What assumption must you make about the population distribution in order to construct the confidence interval estimate in (a)?
c. Do you think that the assumption needed in order to construct the confidence interval estimate in (a) is valid? Explain.
d. Compare the conclusions reached in (a) with those of Problem 2.43 on page 64.

8.3 Confidence Interval Estimate for the Proportion

Student Tip
As noted in Chapter 7, do not confuse this use of the Greek letter pi, π, to represent the population proportion with the mathematical constant that is the ratio of the circumference to a diameter of a circle—approximately 3.14159—which is also known by the same Greek letter.

The concept of a confidence interval also applies to categorical data. With categorical data, you want to estimate the proportion of items in a population having a certain characteristic of interest. The unknown population proportion is represented by the Greek letter π. The point estimate for π is the sample proportion, $p = X/n$, where n is the sample size and X is the number of items in the sample having the characteristic of interest. Equation (8.3) defines the confidence interval estimate for the population proportion.

CONFIDENCE INTERVAL ESTIMATE FOR THE PROPORTION

$$p \pm Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}}$$

or

$$p - Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}} \leq \pi \leq p + Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}} \quad \textbf{(8.3)}$$

where

p = sample proportion $= \dfrac{X}{n} = \dfrac{\text{Number of items having the characteristic}}{\text{sample size}}$
π = population proportion
$Z_{\alpha/2}$ = critical value from the standardized normal distribution
n = sample size

Note: To use this equation for the confidence interval, the sample size n must be large enough to ensure that both X and $n - X$ are greater than 5.

Student Tip
Remember, the sample proportion, p, must be between 0 and 1.

You can use the confidence interval estimate for the proportion defined in Equation (8.3) to estimate the proportion of sales invoices that contain errors (see the Ricknel Home Centers scenario on page 272). Using the DCOVA steps, you define the variable of interest as whether the invoice contains errors (yes or no). Then, you collect the data from a sample of 100 sales invoices. The results, which you organize and store in a worksheet, show that 10 invoices contain errors. To analyze the data, you compute, for these data, $p = X/n = 10/100 = 0.10$. Since both $X = 10$ and $n - X = 100 - 10 = 90$ are > 5, using Equation (8.3) and $Z_{\alpha/2} = 1.96$, for 95% confidence, Equation (8.3) contains a Z statistic because you can use the normal distribution to approximate the binomial distribution when the sample size is sufficiently large. In Example 8.4, the confidence interval using Z provides an excellent approximation for the population proportion because both X and $n - X$ are greater than 5. However, if you do not have a sufficiently large sample size, you should use the binomial distribution rather than Equation (8.3) (see references 1, 3, and 9). The exact confidence intervals for various sample sizes and proportions of items of interest have been tabulated by Fisher and Yates (reference 3) and can also be computed using Minitab.

Problems for Section 8.3

LEARNING THE BASICS

8.26 If $n = 200$ and $X = 50$, construct a 95% confidence interval estimate for the population proportion.

8.27 If $n = 400$ and $X = 25$, construct a 99% confidence interval estimate for the population proportion.

APPLYING THE CONCEPTS

SELF Test **8.28** A cellphone provider has the business objective of wanting to estimate the proportion of subscribers who would upgrade to a new cellphone with improved features if it were made available at a substantially reduced cost. Data are collected from a random sample of 500 subscribers. The results indicate that 135 of the subscribers would upgrade to a new cellphone at a reduced cost.

a. Construct a 99% confidence interval estimate for the population proportion of subscribers that would upgrade to a new cellphone at a reduced cost.

b. How would the manager in charge of promotional programs use the results in (a)?

8.29 In a survey of 3,773 travelers, 1,509 said that location was very important for choosing a hotel and 1,207 said that reputation was very important in choosing an airline. (Data extracted from "Travelers Get Stingy with Their Loyalty," *USA Today*, January 18, 2013, p. 8B.)

a. Construct a 95% confidence interval estimate for the population proportion of travelers who said that location was very important for choosing a hotel.

b. Construct a 95% confidence interval estimate for the population proportion of travelers who said that reputation was very important in choosing an airline.

c. Write a short summary of the information derived from (a) and (b).

8.30 Are you more likely to purchase a brand mentioned by an athlete on a social media site? According to a Catalyst Digital Fan Engagement survey, 53% of social media sports fans would make such a purchase. (Data extracted from "Survey: Social Media Continues to Fuel Fans," *Sports Business Journal*, July 16, 2012, p. 24.)

a. Suppose that the survey had a sample size of $n = 500$. Construct a 95% confidence interval estimate for the population proportion of social media sports fans that would more likely purchase a brand mentioned by an athlete on a social media site.

b. Based on (a), can you claim that more than half of all social media sports fans would more likely purchase a brand mentioned by an athlete on a social media site?

c. Repeat parts (a) and (b), assuming that the survey had a sample size of $n = 5{,}000$.

d. Discuss the effect of sample size on confidence interval estimation.

8.31 In a survey of 280 qualified readers of *Logistics Management*, 62 responded that the "cloud" and Software as a Service (SaaS) is not an option for their firms, citing issues such as security and privacy concerns, system reliability and system performance, data integrity, and lack of control as the biggest concerns. (Data extracted from "2012 Supply Chain Software Users Survey: Spending Stabilizers," *Logistics Management*, May 2012, p. 38.) Construct a 95% confidence interval estimate for the population proportion of logistics firms for which the cloud and SaaS is not an option.

8.32 In a survey of 1,954 cellphone owners, adults aged 18 and over, 743 reported that they use their phone to keep themselves occupied during commercials or breaks in something they were watching on television, while 430 used their phone to check whether something they heard on television is true. (Data extracted from "The Rise of the Connected Viewer," Pew Research Center's Internet & American Life Project, July 17, 2012, **pewinternet.org/~/media//Files/Reports/2012/PIP_Connected_Viewers.pdf**.)

a. Construct a 95% confidence interval estimate for the population proportion of adult cellphone owners who report that they use their phone to keep themselves occupied during commercials or breaks in something they were watching on television.

b. Construct a 95% confidence interval estimate for the population proportion of adult cellphone owners who report that they use their phone to check whether something they heard on television was true.

c. Compare the results of (a) and (b).

8.33 What are the factors that influence technology (tech) CEOs' anticipated need to change strategy? In a survey by PricewaterhouseCoopers (PwC), 94 of 115 tech CEOs around the globe responded that customer demand is one of the reasons they are making strategic changes at their organization, and 40 responded that availability of talent is one of the reasons. (Data extracted from "Delivering Results: Key Findings in the Technology Sector," 15th Annual PwC Global CEO Survey, 2012.)

a. Construct a 95% confidence interval estimate for the population proportion of tech CEOs who indicate customer demand as one of the reasons for making strategic change.

b. Construct a 95% confidence interval estimate for the population proportion of tech CEOs who indicate availability of talent as one of the reasons for making strategic change.

c. Interpret the intervals in (a) and (b).

Example 8.6 provides another application of determining the sample size for estimating the population proportion.

EXAMPLE 8.6

Determining the Sample Size for the Population Proportion

You want to have 90% confidence of estimating the proportion of office workers who respond to email within an hour to within ± 0.05. Because you have not previously undertaken such a study, there is no information available from past data. Determine the sample size needed.

SOLUTION Because no information is available from past data, assume that $\pi = 0.50$. Using Equation (8.5) on page 292 and $e = 0.05$, $\pi = 0.50$, and $Z_{a/2} = 1.645$ for 90% confidence,

$$n = \frac{Z_{\alpha/2}^2 \pi(1 - \pi)}{e^2}$$

$$= \frac{(1.645)^2(0.50)(0.50)}{(0.05)^2}$$

$$= 270.6$$

Therefore, you need a sample of 271 office workers to estimate the population proportion to within ± 0.05 with 90% confidence.

Problems for Section 8.4

LEARNING THE BASICS

8.34 If you want to be 95% confident of estimating the population mean to within a sampling error of ± 5 and the standard deviation is assumed to be 15, what sample size is required?

8.35 If you want to be 99% confident of estimating the population mean to within a sampling error of ± 20 and the standard deviation is assumed to be 100, what sample size is required?

8.36 If you want to be 99% confident of estimating the population proportion to within a sampling error of ± 0.04, what sample size is needed?

8.37 If you want to be 95% confident of estimating the population proportion to within a sampling error of ± 0.02 and there is historical evidence that the population proportion is approximately 0.40, what sample size is needed?

APPLYING THE CONCEPTS

8.38 A survey is planned to determine the mean annual family medical expenses of employees of a large company. The management of the company wishes to be 95% confident that the sample mean is correct to within $\pm \$50$ of the population mean annual family medical expenses. A previous study indicates that the standard deviation is approximately \$400.

a. How large a sample is necessary?

b. If management wants to be correct to within $\pm \$25$, how many employees need to be selected?

8.39 If the manager of a bottled water distributor wants to estimate, with 95% confidence, the mean amount of water in a 1-gallon bottle to within ± 0.004 gallon and also assumes that the standard deviation is 0.02 gallon, what sample size is needed?

8.40 If a light bulb manufacturing company wants to estimate, with 95% confidence, the mean life of compact fluorescent light bulbs to within ± 200 hours and also assumes that the population standard deviation is 1,000 hours, how many compact fluorescent light bulbs need to be selected?

8.41 If the inspection division of a county weights and measures department wants to estimate the mean amount of soft-drink fill in 2-liter bottles to within ± 0.01 liter with 95% confidence and also assumes that the standard deviation is 0.05 liter, what sample size is needed?

8.42 An advertising executive wants to estimate the mean weekly amount of time 18- to 24-year-olds spend watching traditional television in a large city. Based on studies in other cities, the standard deviation is assumed to be 10 minutes. The executive wants to estimate, with 99% confidence, the mean weekly amount of time to within ± 3 minutes.

a. What sample size is needed?

b. If 95% confidence is desired, how many 18- to 24-year-olds need to be selected?

8.43 An advertising agency that serves a major radio station wants to estimate the mean amount of time that the station's audience spends listening to the radio daily. From past studies, the standard deviation is estimated as 45 minutes.

a. What sample size is needed if the agency wants to be 90% confident of being correct to within ± 5 minutes?

b. If 99% confidence is desired, how many listeners need to be selected?

8.44 A growing niche in the restaurant business is gourmet-casual breakfast, lunch, and brunch. Chains in this group include EggSpectation and Panera Bread. Suppose that the mean per-person check for breakfast at EggSpectation is approximately \$14.50, and the mean per-person check for Panera Bread is \$8.50.

a. Assuming a standard deviation of \$2.00, what sample size is needed to estimate, with 95% confidence, the mean per-person check for EggSpectation to within $\pm$\$0.25?

b. Assuming a standard deviation of \$2.50, what sample size is needed to estimate, with 95% confidence, the mean per-person check for EggSpectation to within $\pm$\$0.25?

c. Assuming a standard deviation of \$3.00, what sample size is needed to estimate, with 95% confidence, the mean per-person check for EggSpectation to within $\pm$\$0.25?

d. Discuss the effect of variation on the sample size needed.

8.45 What advertising medium is most influential in making a purchase decision? According to a TVB survey, 37.2% of American adults point to TV. (Data extracted from "TV Seen Most Influential Ad Medium for Purchase Decisions," *MC Marketing Charts*, June 18, 2012.)

a. To conduct a follow-up study that would provide 95% confidence that the point estimate is correct to within ± 0.04 of the population proportion, how large a sample size is required?

b. To conduct a follow-up study that would provide 99% confidence that the point estimate is correct to within ± 0.04 of the population proportion, how many people need to be sampled?

c. To conduct a follow-up study that would provide 95% confidence that the point estimate is correct to within ± 0.02 of the population proportion, how large a sample size is required?

d. To conduct a follow-up study that would provide 99% confidence that the point estimate is correct to within ± 0.02 of the population proportion, how many people need to be sampled?

e. Discuss the effects on sample size requirements of changing the desired confidence level and the acceptable sampling error.

8.46 A survey of 300 U.S. online shoppers was conducted. In response to the question of what would influence the shopper to spend more money online in 2012, 18% said free shipping, 13% said offering discounts while shopping, and 9% said product reviews. (Data extracted from "2012 Consumer Shopping Trends and Insights," Steelhouse, Inc., 2012.) Construct a 95% confidence interval estimate of the population proportion of online shoppers who would be influenced to spend more money online in 2012 with

a. free shipping.

b. discounts offered while shopping.

c. product reviews.

d. You have been asked to update the results of this study. Determine the sample size necessary to estimate, with 95% confidence, the population proportions in (a) through (c) to within ± 0.02.

8.47 In a study of 368 San Francisco Bay Area nonprofits, 224 reported that they are collaborating with other organizations to provide services, a necessity as nonprofit agencies are called upon to do more with less. (Data extracted from "2012 Nonprofit Pulse Survey," United Way of the Bay Area, 2012, **bit.ly/MkGINA**.)

a. Construct a 95% confidence interval for the proportion of San Francisco Bay Area nonprofits that collaborated with other organizations to provide services.

b. Interpret the interval constructed in (a).

c. If you wanted to conduct a follow-up study to estimate the population proportion of San Francisco Bay Area nonprofits that collaborated with other organizations to provide service to within ± 0.01 with 95% confidence, how may Bay Area nonprofits would you survey?

8.48 According to a new study released by Infosys, a global leader in consulting, outsourcing, and technology, more than three-quarters (77%) of U.S. consumers say that banking on their mobile device is convenient. (Data extracted from "Infosys Survey Finds Mobile Banking Customers Love Ease and Convenience, Yet Reliability and Security Concerns Remain," *PR Newswire*, 2012, **bit.ly/Ip9RUF**.)

a. If you conduct a follow-up study to estimate the population proportion of U.S. consumers who say that banking on their mobile device is convenient, would you use a π of 0.77 or 0.50 in the sample size formula?

b. Using you answer in part (a), find the sample size necessary to estimate, with 95% confidence, the population proportion to within ± 0.03.

8.49 Which store do you think is more expensive—physical or online? A recent survey (*USA Today*, December 10, 2012, p. 1B) found that 46% of people aged 20 to 40 thought that physical stores were more expensive.

a. To conduct a follow-up study that would provide 99% confidence that the point estimate is correct to within ± 0.03 of the population proportion, how many people aged 20 to 40 need to be sampled?

b. To conduct a follow-up study that would provide 99% confidence that the point estimate is correct to within ± 0.05 of the population proportion, how many people aged 20 to 40 need to be sampled?

c. Compare the results of (a) and (b).

8.5 Confidence Interval Estimation and Ethical Issues

The selection of samples and the inferences that accompany them raise several ethical issues. The major ethical issue concerns whether confidence interval estimates accompany point estimates. Failure to include a confidence interval estimate might mislead the user of the results into thinking that the point estimate is all that is needed to predict the population characteristic with certainty. Confidence interval limits (typically set at 95%), the sample size used, and an interpretation of the meaning of the confidence interval in terms that a person untrained in statistics can understand should always accompany point estimates.

When media outlets publicize the results of a political poll, they often overlook including this type of information. Sometimes, the results of a poll include the sampling error, but the sampling error is often presented in fine print or as an afterthought to the story being reported.

SUMMARY

This chapter discusses confidence intervals for estimating the characteristics of a population, along with how you can determine the necessary sample size. You learned how to apply these methods to numerical and categorical data. Table 8.3 provides a list of topics covered in this chapter.

To determine what equation to use for a particular situation, you need to answer these questions:

- Are you constructing a confidence interval, or are you determining sample size?
- Do you have a numerical variable, or do you have a categorical variable?

The next four chapters develop a hypothesis-testing approach to making decisions about population parameters.

TABLE 8.3

Summary of Topics in Chapter 8

	TYPE OF DATA	
TYPE OF ANALYSIS	**Numerical**	**Categorical**
Confidence interval for a population parameter	Confidence interval estimate for the mean (Sections 8.1 and 8.2)	Confidence interval estimate for the proportion (Section 8.3)
Determining sample size	Sample size determination for the mean (Section 8.4)	Sample size determination for the proportion (Section 8.4)

REFERENCES

1. Cochran, W. G. *Sampling Techniques*, 3rd ed. New York: Wiley, 1977.
2. Daniel, W. W. *Applied Nonparametric Statistics*, 2nd ed. Boston: PWS Kent, 1990.
3. Fisher, R. A., and F. Yates. *Statistical Tables for Biological, Agricultural and Medical Research*, 5th ed. Edinburgh: Oliver & Boyd, 1957.
4. Hahn, G., and W. Meeker. *Statistical Intervals: A Guide for Practitioners*. New York: John Wiley and Sons, Inc., 1991.
5. Kirk, R. E., ed. *Statistical Issues: A Reader for the Behavioral Sciences*. Belmont, CA: Wadsworth, 1972.
6. Larsen, R. L., and M. L. Marx. *An Introduction to Mathematical Statistics and Its Applications*, 4th ed. Upper Saddle River, NJ: Prentice Hall, 2006.
7. *Microsoft Excel 2013*. Redmond, WA: Microsoft Corp., 2012.
8. *Minitab Release 16*. State College, PA: Minitab, Inc., 2010.
9. Snedecor, G. W., and W. G. Cochran. *Statistical Methods*, 7th ed. Ames, IA: Iowa State University Press, 1980.

KEY EQUATIONS

Confidence Interval for the Mean (σ Known)

$$\overline{X} \pm Z_{\alpha/2}\frac{\sigma}{\sqrt{n}}$$

or

$$\overline{X} - Z_{\alpha/2}\frac{\sigma}{\sqrt{n}} \le \mu \le \overline{X} + Z_{\alpha/2}\frac{\sigma}{\sqrt{n}} \quad \textbf{(8.1)}$$

Confidence Interval for the Mean (σ Unknown)

$$\overline{X} \pm t_{\alpha/2}\frac{S}{\sqrt{n}}$$

or

$$\overline{X} - t_{\alpha/2}\frac{S}{\sqrt{n}} \le \mu \le \overline{X} + t_{\alpha/2}\frac{S}{\sqrt{n}} \quad \textbf{(8.2)}$$

Confidence Interval Estimate for the Proportion

$$p \pm Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}}$$

or

$$p - Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}} \le \pi \le p + Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}} \quad \textbf{(8.3)}$$

Sample Size Determination for the Mean

$$n = \frac{Z^2_{\alpha/2}\sigma^2}{e^2} \quad \textbf{(8.4)}$$

Sample Size Determination for the Proportion

$$n = \frac{Z^2_{\alpha/2}\pi(1-\pi)}{e^2} \quad \textbf{(8.5)}$$

KEY TERMS

confidence interval estimate 273
critical value 277
degrees of freedom 279
level of confidence 276
margin of error 290
point estimate 273
sampling error 276
Student's t distribution 279

CHECKING YOUR UNDERSTANDING

8.50 Why can you never really have 100% confidence of correctly estimating the population characteristic of interest?

8.51 When should you use the t distribution to develop the confidence interval estimate for the mean?

8.52 Why is it true that for a given sample size, n, an increase in confidence is achieved by widening (and making less precise) the confidence interval?

8.53 Why is the sample size needed to determine the proportion smaller when the population proportion is 0.20 than when the population proportion is 0.50?

CHAPTER REVIEW PROBLEMS

8.54 The Pew Internet Project survey of 2,253 American adults (data extracted from **pewinternet.org/Commentary/2012/February/Pew-Internet-Mobile**) found the following:

1,983 have a cellphone
1,307 have a desktop computer
1,374 have a laptop computer
406 have an ebook reader
406 have a tablet computer

a. Construct 95% confidence interval estimates for the population proportion of the electronic devices adults own.
b. What conclusions can you reach concerning what electronic devices adults have?

8.55 What do Americans do to conserve energy? The Associated Press-NORC Center for Public Affairs Research conducted a survey of 897 adults who had personally done something to try to save energy in the last year (data extracted from "Energy Efficiency and Independence: How the Public Understands, Learns, and Acts," **bit.ly/Maw5hd**), and found the following percentages:

Turn off lights: 39%
Turn down heat: 26%
Install more energy-saving appliances: 23%
Drive less/walk more/bicycle more: 18%
Unplug things: 16%

a. Construct a 95% confidence interval estimate for the population proportion of what adults do to conserve energy.
b. What conclusions can you reach concerning what adults do to conserve energy?

8.56 A market researcher for a consumer electronics company wants to study the media viewing behavior of residents of a particular area. A random sample of 40 respondents is selected, and each respondent is instructed to keep a detailed record of time spent engaged viewing content across all screens (traditional TV, DVD/Blu-ray, game console, Internet on a computer, video on a computer, video on a mobile phone) in a particular week. The results are as follows:

- Content viewing time per week: $\bar{X} = 41$ hours, $S = 3.5$ hours.
- 30 respondents have high definition (HD) on at least one television set.

a. Construct a 95% confidence interval estimate for the mean content viewing time per week in this area.
b. Construct a 95% confidence interval estimate for the population proportion of residents who have HD on at least one television set.

Suppose that the market researcher wants to take another survey in a different location. Answer these questions:

c. What sample size is required to be 95% confident of estimating the population mean content viewing time to within ± 2 hours assuming that the population standard deviation is equal to 5 hours?
d. How many respondents need to be selected to be 95% confident of being within ± 0.06 of the population proportion who have HD on at least one television set if no previous estimate is available?
e. Based on (c) and (d), how many respondents should the market researcher select if a single survey is being conducted?

8.57 An information technology (IT) consulting firm specializing in healthcare solutions wants to study communication deficiencies in the health care industry. A random sample of 70 health care clinicians reveals the following:

- Time wasted in a day due to outdated communication technologies: $\bar{X} = 45$ minutes, $S = 10$ minutes.
- Thirty-six health care clinicians cite inefficiency of pagers as the reason for the wasted time.

a. Construct a 99% confidence interval estimate for the population mean time wasted in a day due to outdated communication technologies.
b. Construct a 95% confidence interval estimate for the population proportion of health care clinicians who cite inefficiency of pagers as the reason for the wasted time.

8.58 The human resource (HR) director of a large corporation wishes to study absenteeism among its mid-level managers at its central office during the year. A random sample of 25 mid-level managers reveals the following:

- Absenteeism: $\overline{X} = 6.2$ days, $S = 7.3$ days.
- 13 mid-level managers cite stress as a cause of absence.

a. Construct a 95% confidence interval estimate for the mean number of absences for mid-level managers during the year.
b. Construct a 95% confidence interval estimate for the population proportion of mid-level managers who cite stress as a cause of absence.

Suppose that the HR director wishes to administer a survey in one of its regional offices. Answer these questions:

c. What sample size is needed to have 95% confidence in estimating the population mean absenteeism to within ± 1.5 days if the population standard deviation is estimated to be 8 days?
d. How many mid-level managers need to be selected to have 90% confidence in estimating the population proportion of mid-level managers who cite stress as a cause of absence to within ± 0.075 if no previous estimate is available?
e. Based on (c) and (d), what sample size is needed if a single survey is being conducted?

8.59 A national association devoted to human resource (HR) and workplace programs, practices, and training wants to study HR department practices and employee turnover of its member organizations. HR professionals and organization executives focus on turnover not only because it has significant cost implications but also because it affects overall business performance. A survey is designed to estimate the proportion of member organizations that have both talent and development programs in place to drive human-capital management as well as the member organizations' mean annual employee turnover rate (the ratio of the number of employees that left an organization in a given time period to the average number of employees in the organization during the given time period). A random sample of 100 member organizations reveals the following:

- Annual turnover rate: $\overline{X} = 8.1\%$, $S = 1.5\%$.
- Thirty member organizations have both talent and development programs in place to drive human-capital management.

a. Construct a 95% confidence interval estimate for the population mean annual turnover rate of member organizations.
b. Construct a 95% confidence interval estimate for the population proportion of member organizations that have both talent and development programs in place to drive human-capital management.
c. What sample size is needed to have 99% confidence of estimating the population mean annual employee turnover rate to within $\pm 1.5\%$?
d. How many member organizations need to be selected to have 90% confidence of estimating the population proportion of organizations that have both talent and development programs in place to drive human-capital management to within $\pm .045$?

8.60 The financial impact of IT systems downtime is a concern of plant operations management today. A survey of manufacturers examined the satisfaction level with the reliability and availability of their manufacturing IT applications. The variables of focus are whether the manufacturer experienced downtime in the past year that affected one or more manufacturing IT applications, the number of downtime incidents that occurred in the past year, and the approximate cost of a typical downtime incident. The results from a sample of 200 manufacturers are as follows:

- Sixty-two experienced downtime this year that affected one or more manufacturing applications.
- Number of downtime incidents: $\overline{X} = 3.5$, $S = 2.0$
- Cost of downtime incidents: $\overline{X} = \$18{,}000$, $S = \$3{,}000$.

a. Construct a 90% confidence interval estimate for the population proportion of manufacturers who experienced downtime in the past year that affected one or more manufacturing IT applications.
b. Construct a 95% confidence interval estimate for the population mean number of downtime incidents experienced by manufacturers in the past year.
c. Construct a 95% confidence interval estimate for the population mean cost of downtime incidents.

8.61 The branch manager of an outlet (Store 1) of a nationwide chain of pet supply stores wants to study characteristics of her customers. In particular, she decides to focus on two variables: the amount of money spent by customers and whether the customers own only one dog, only one cat, or more than one dog and/or cat. The results from a sample of 70 customers are as follows:

- Amount of money spent: $\overline{X} = \$21.34$, $S = \$9.22$.
- Thirty-seven customers own only a dog.
- Twenty-six customers own only a cat.
- Seven customers own more than one dog and/or cat.

a. Construct a 95% confidence interval estimate for the population mean amount spent in the pet supply store.
b. Construct a 90% confidence interval estimate for the population proportion of customers who own only a cat.

The branch manager of another outlet (Store 2) wishes to conduct a similar survey in his store. The manager does not have access to the information generated by the manager of Store 1. Answer the following questions:

c. What sample size is needed to have 95% confidence of estimating the population mean amount spent in this store to within $\pm \$1.50$ if the standard deviation is estimated to be \$10?
d. How many customers need to be selected to have 90% confidence of estimating the population proportion of customers who own only a cat to within ± 0.045?
e. Based on your answers to (c) and (d), how large a sample should the manager take?

8.62 Scarlett and Heather, the owners of an upscale restaurant in Dayton, Ohio, want to study the dining characteristics of their customers. They decide to focus on two variables: the amount of money spent by customers and whether customers order dessert. The results from a sample of 60 customers are as follows:

- Amount spent: $\overline{X} = \$38.54$, $S = \$7.26$.
- Eighteen customers purchased dessert.

a. Construct a 95% confidence interval estimate for the population mean amount spent per customer in the restaurant.
b. Construct a 90% confidence interval estimate for the population proportion of customers who purchase dessert.

Jeanine, the owner of a competing restaurant, wants to conduct a similar survey in her restaurant. Jeanine does not have access to the information that Scarlett and Heather have obtained from the survey they conducted. Answer the following questions:

c. What sample size is needed to have 95% confidence of estimating the population mean amount spent in her restaurant to within $\pm\$1.50$, assuming that the standard deviation is estimated to be \$8?

d. How many customers need to be selected to have 90% confidence of estimating the population proportion of customers who purchase dessert to within ± 0.04?

e. Based on your answers to (c) and (d), how large a sample should Jeanine take?

8.63 The manufacturer of Ice Melt claims that its product will melt snow and ice at temperatures as low as 0° Fahrenheit. A representative for a large chain of hardware stores is interested in testing this claim. The chain purchases a large shipment of 5-pound bags for distribution. The representative wants to know, with 95% confidence and within ± 0.05, what proportion of bags of Ice Melt perform the job as claimed by the manufacturer.

a. How many bags does the representative need to test? What assumption should be made concerning the population proportion? (This is called *destructive testing*; i.e., the product being tested is destroyed by the test and is then unavailable to be sold.)

b. Suppose that the representative tests 50 bags, and 42 of them do the job as claimed. Construct a 95% confidence interval estimate for the population proportion that will do the job as claimed.

c. How can the representative use the results of (b) to determine whether to sell the Ice Melt product?

8.64 Claims fraud (illegitimate claims) and buildup (exaggerated loss amounts) continue to be major issues of concern among automobile insurance companies. Fraud is defined as specific material misrepresentation of the facts of a loss; buildup is defined as the inflation of an otherwise legitimate claim. A recent study examined auto injury claims closed with payment under private passenger coverages. Detailed data on injury, medical treatment, claimed losses, and total payments, as well as claim-handling techniques, were collected. In addition, auditors were asked to review the claim files to indicate whether specific elements of fraud or buildup appeared in the claim and, in the case of buildup, to specify the amount of excess payment. The file **InsuranceClaims** contains data for 90 randomly selected auto injury claims. The following variables are included: CLAIM—Claim ID; BUILDUP—1 if buildup indicated, 0 if not; and EXCESSPAYMENT—excess payment amount, in dollars.

a. Construct a 95% confidence interval for the population proportion of all auto injury files that have exaggerated loss amounts.

b. Construct a 95% confidence interval for the population mean dollar excess payment amount.

8.65 A quality characteristic of interest for a teabag-filling process is the weight of the tea in the individual bags. In this example, the label weight on the package indicates that the mean amount is 5.5 grams of tea in a bag. If the bags are underfilled, two problems arise. First, customers may not be able to brew the tea to be as strong as they wish. Second, the company may be in violation of the truth-in-labeling laws. On the other hand, if the mean amount of tea in a bag exceeds the label weight, the company is giving away product. Getting an exact amount of tea in a bag is problematic because of variation in the temperature and humidity inside the factory, differences in the density of the tea, and the extremely fast filling operation of the machine (approximately 170 bags per minute). The following data (stored in **Teabags**) are the weights, in grams, of a sample of 50 tea bags produced in one hour by a single machine:

5.65	5.44	5.42	5.40	5.53	5.34	5.54	5.45	5.52	5.41
5.57	5.40	5.53	5.54	5.55	5.62	5.56	5.46	5.44	5.51
5.47	5.40	5.47	5.61	5.53	5.32	5.67	5.29	5.49	5.55
5.77	5.57	5.42	5.58	5.58	5.50	5.32	5.50	5.53	5.58
5.61	5.45	5.44	5.25	5.56	5.63	5.50	5.57	5.67	5.36

a. Construct a 99% confidence interval estimate for the population mean weight of the tea bags.

b. Is the company meeting the requirement set forth on the label that the mean amount of tea in a bag is 5.5 grams?

c. Do you think the assumption needed to construct the confidence interval estimate in (a) is valid?

8.66 A manufacturing company produces steel housings for electrical equipment. The main component part of the housing is a steel trough that is made from a 14-gauge steel coil. It is produced using a 250-ton progressive punch press with a wipe-down operation that puts two 90-degree forms in the flat steel to make the trough. The distance from one side of the form to the other is critical because of weatherproofing in outdoor applications. The widths (in inches), shown below and stored in **Trough**, are from a sample of 49 troughs:

8.312	8.343	8.317	8.383	8.348	8.410	8.351	8.373	8.481
8.422	8.476	8.382	8.484	8.403	8.414	8.419	8.385	8.465
8.498	8.447	8.436	8.413	8.489	8.414	8.481	8.415	8.479
8.429	8.458	8.462	8.460	8.444	8.429	8.460	8.412	8.420
8.410	8.405	8.323	8.420	8.396	8.447	8.405	8.439	8.411
8.427	8.420	8.498	8.409					

a. Construct a 95% confidence interval estimate for the mean width of the troughs.

b. Interpret the interval developed in (a).

c. Do you think the assumption needed to construct the confidence interval estimate in (a) in valid?

8.67 The manufacturer of Boston and Vermont asphalt shingles knows that product weight is a major factor in a customer's perception of quality. The last stage of the assembly line packages the shingles before they are placed on wooden pallets. Once a pallet is full (a pallet for most brands holds 16 squares of shingles), it is weighed, and the measurement is recorded. The file **Pallet** contains the weight (in pounds) from a sample of 368 pallets of Boston shingles and 330 pallets of Vermont shingles.

a. For the Boston shingles, construct a 95% confidence interval estimate for the mean weight.

b. For the Vermont shingles, construct a 95% confidence interval estimate for the mean weight.

c. Do you think the assumption needed to construct the confidence interval estimates in (a) and (b) is valid?

d. Based on the results of (a) and (b), what conclusions can you reach concerning the mean weight of the Boston and Vermont shingles?

8.68 The manufacturer of Boston and Vermont asphalt shingles provides its customers with a 20-year warranty on most of its products. To determine whether a shingle will last the entire warranty period, accelerated-life testing is conducted at the manufacturing plant. Accelerated-life testing exposes the shingle to the stresses it would be subject to in a lifetime of normal use via a laboratory experiment that takes only a few minutes to conduct. In this test, a shingle is repeatedly scraped with a brush for a short period of time, and the shingle granules removed by the brushing are weighed (in grams). Shingles that experience low amounts of granule loss are expected to last longer in normal use than shingles that experience high amounts of granule loss. In this situation, a shingle should experience no more than 0.8 grams of granule loss if it is expected to last the length of the warranty period. The file **Granule** contains a sample of 170 measurements made on the company's Boston shingles and 140 measurements made on Vermont shingles.

a. For the Boston shingles, construct a 95% confidence interval estimate for the mean granule loss.
b. For the Vermont shingles, construct a 95% confidence interval estimate for the mean granule loss.
c. Do you think the assumption needed to construct the confidence interval estimates in (a) and (b) is valid?
d. Based on the results of (a) and (b), what conclusions can you reach concerning the mean granule loss of the Boston and Vermont shingles?

REPORT WRITING EXERCISE

8.69 Referring to the results in Problem 8.66 concerning the width of a steel trough, write a report that summarizes your conclusions.

CASES FOR CHAPTER 8

Managing Ashland MultiComm Services

The marketing department has been considering ways to increase the number of new subscriptions to the *3-For-All* cable/phone/Internet service. Following the suggestion of Assistant Manager Lauren Adler, the department staff designed a survey to help determine various characteristics of households who subscribe to cable television service from Ashland. The survey consists of the following 10 questions:

1. Does your household subscribe to telephone service from Ashland?
   (1) Yes (2) No
2. Does your household subscribe to Internet service from Ashland?
   (1) Yes (2) No
3. What type of cable television service do you have?
   (1) Basic (2) Enhanced
   (If Basic, skip to question 5.)
4. How often do you watch the cable television stations that are only available with enhanced service?
   (1) Every day (2) Most days
   (3) Occasionally or never
5. How often do you watch premium or on-demand services that require an extra fee?
   (1) Almost every day (2) Several times a week
   (3) Rarely (4) Never
6. Which method did you use to obtain your current AMS subscription?
   (1) AMS toll-free phone number
   (2) AMS website
   (3) Direct mail reply card
   (4) Good Tunes & More promotion
   (5) Other
7. Would you consider subscribing to the *3-For-All* cable/phone/Internet service for a trial period if a discount were offered?
   (1) Yes (2) No
   (If no, skip to question 9.)
8. If purchased separately, cable, Internet, and phone services would currently cost $24.99 per week. How much would you be willing to pay per week for the *3-For-All* cable/phone/Internet service?
9. Does your household use another provider of telephone service?
   (1) Yes (2) No
10. AMS may distribute Ashland Gold Cards that would provide discounts at selected Ashland-area restaurants for subscribers who agree to a two-year subscription contract to the *3-For-All* service. Would being eligible to receive a Gold Card cause you to agree to the two-year term?
    (1) Yes (2) No

Of the 500 households selected that subscribe to cable television service from Ashland, 82 households either refused to participate, could not be contacted after repeated attempts,