Exercises 8.2

Understanding the Concepts and Skills

8.13 Find the confidence level and α for
a. a 90% confidence interval.
b. a 99% confidence interval.

8.14 Find the confidence level and α for
a. an 85% confidence interval.
b. a 95% confidence interval.

8.15 What is meant by saying that a $1 - \alpha$ confidence interval is
a. exact?
b. approximately correct?

8.16 In developing Procedure 8.1, we assumed that the variable under consideration is normally distributed.
a. Explain why we needed that assumption.
b. Explain why the procedure yields an approximately correct confidence interval for large samples, regardless of the distribution of the variable under consideration.

8.17 For what is *normal population* an abbreviation?

8.18 Refer to Procedure 8.1.
a. Explain in detail the assumptions required for using the z-interval procedure.
b. How important is the normality assumption? Explain your answer.

8.19 What is meant by saying that a statistical procedure is robust?

8.20 In each part, assume that the population standard deviation is known. Decide whether use of the z-interval procedure to obtain a confidence interval for the population mean is reasonable. Explain your answers.
a. The variable under consideration is very close to being normally distributed, and the sample size is 10.
b. The variable under consideration is very close to being normally distributed, and the sample size is 75.
c. The sample data contain outliers, and the sample size is 20.

8.21 In each part, assume that the population standard deviation is known. Decide whether use of the z-interval procedure to obtain a confidence interval for the population mean is reasonable. Explain your answers.
a. The sample data contain no outliers, the variable under consideration is roughly normally distributed, and the sample size is 20.
b. The distribution of the variable under consideration is highly skewed, and the sample size is 20.
c. The sample data contain no outliers, the sample size is 250, and the variable under consideration is far from being normally distributed.

8.22 Suppose that you have obtained data by taking a random sample from a population. Before performing a statistical inference, what should you do?

8.23 Suppose that you have obtained data by taking a random sample from a population and that you intend to find a confidence interval for the population mean, μ. Which confidence level, 95% or 99%, will result in the confidence interval's giving a more precise estimate of μ?

8.24 If a good typist can input 70 words per minute, but a 99% confidence interval for the mean number of words input per minute by recent applicants lies entirely below 70, what can you conclude about the typing skills of recent applicants?

In each of Exercises 8.25–8.30, we provide a sample mean, sample size, population standard deviation, and confidence level. In each case, use the one-mean z-interval procedure to find a confidence interval for the mean of the population from which the sample was drawn.

8.25 $\bar{x} = 20$, $n = 36$, $\sigma = 3$, confidence level = 95%

8.26 $\bar{x} = 25$, $n = 36$, $\sigma = 3$, confidence level = 95%

8.27 $\bar{x} = 30$, $n = 25$, $\sigma = 4$, confidence level = 90%

8.28 $\bar{x} = 35$, $n = 25$, $\sigma = 4$, confidence level = 90%

8.29 $\bar{x} = 50$, $n = 16$, $\sigma = 5$, confidence level = 99%

8.30 $\bar{x} = 55$, $n = 16$, $\sigma = 5$, confidence level = 99%

Preliminary data analyses indicate that you can reasonably apply the z-interval procedure (Procedure 8.1 on page 330) in Exercises 8.31–8.36.

8.31 Venture-Capital Investments. Data on investments in the high-tech industry by venture capitalists are compiled by VentureOne Corporation and published in *America's Network Telecom Investor Supplement*. A random sample of 18 venture-capital investments in the fiber optics business sector yielded the following data, in millions of dollars.

5.60	6.27	5.96	10.51	2.04	5.48
5.74	5.58	4.13	8.63	5.95	6.67
4.21	7.71	9.21	4.98	8.64	6.66

a. Determine a 95% confidence interval for the mean amount, μ, of all venture-capital investments in the fiber optics business sector. Assume that the population standard deviation is \$2.04 million. (*Note:* The sum of the data is \$113.97 million.)
b. Interpret your answer from part (a).

8.32 Poverty and Dietary Calcium. Calcium is the most abundant mineral in the human body and has several important functions. Most body calcium is stored in the bones and teeth, where it functions to support their structure. Recommendations for calcium are provided in *Dietary Reference Intakes*, developed by the Institute of Medicine of the National Academy of Sciences. The recommended adequate intake (RAI) of calcium for adults (ages 19–50) is 1000 milligrams (mg) per day. A simple random sample of 18 adults with incomes below the poverty level gave the following daily calcium intakes.

886	633	943	847	934	841
1193	820	774	834	1050	1058
1192	975	1313	872	1079	809

a. Determine a 95% confidence interval for the mean calcium intake, μ, of all adults with incomes below the poverty level. Assume that the population standard deviation is 188 mg. (*Note:* The sum of the data is 17,053 mg.)
b. Interpret your answer from part (a).

8.33 Toxic Mushrooms? Cadmium, a heavy metal, is toxic to animals. Mushrooms, however, are able to absorb and accumulate cadmium at high concentrations. The Czech and Slovak governments have set a safety limit for cadmium in dry vegetables at 0.5 part per million (ppm). M. Melgar et al. measured the cadmium levels in a random sample of the edible mushroom *Boletus pinicola* and published the results in the paper "Influence of Some Factors in Toxicity and Accumulation of Cd from Edible Wild Macrofungi in NW Spain (*Journal of Environmental Science and Health*, Vol. B33(4), pp. 439–455). Here are the data obtained by the researchers.

0.24	0.59	0.62	0.16	0.77	1.33
0.92	0.19	0.33	0.25	0.59	0.32

Find and interpret a 99% confidence interval for the mean cadmium level of all *Boletus pinicola* mushrooms. Assume a population standard deviation of cadmium levels in *Boletus pinicola* mushrooms of 0.37 ppm. (*Note:* The sum of the data is 6.31 ppm.)

8.34 Smelling Out the Enemy. Snakes deposit chemical trails as they travel through their habitats. These trails are often detected and recognized by lizards, which are potential prey. The ability to recognize their predators via tongue flicks can often mean life or death for lizards. Scientists from the University of Antwerp were interested in quantifying the responses of juveniles of the common lizard (*Lacerta vivipara*) to natural predator cues to determine whether the behavior is learned or congenital. Seventeen juvenile common lizards were exposed to the chemical cues of the viper snake. Their responses, in number of tongue flicks per 20 minutes, are presented in the following table. [SOURCE: Van Damme et al., "Responses of Naïve Lizards to Predator Chemical Cues," *Journal of Herpetology*, Vol. 29(1), pp. 38–43]

425	510	629	236	654	200
276	501	811	332	424	674
676	694	710	662	633	

Find and interpret a 90% confidence interval for the mean number of tongue flicks per 20 minutes for all juvenile common lizards. Assume a population standard deviation of 190.0.

8.35 Political Prisoners. A. Ehlers et al. studied various characteristics of political prisoners from the former East Germany and presented their findings in the paper "Posttraumatic Stress Disorder (PTSD) Following Political Imprisonment: The Role of Mental Defeat, Alienation, and Perceived Permanent Change" (*Journal of Abnormal Psychology*, Vol. 109, pp. 45–55). According to the article, the mean duration of imprisonment for 32 patients with chronic PTSD was 33.4 months. Assuming that $\sigma = 42$ months, determine a 95% confidence interval for the mean duration of imprisonment, μ, of all East German political prisoners with chronic PTSD. Interpret your answer in words.

8.36 Keep on Rolling. The Rolling Stones, a rock group formed in the 1960s, have toured extensively in support of new albums. *Pollstar* has collected data on the earnings from the Stones's North American tours. For 30 randomly selected Rolling Stones concerts, the mean gross earnings is \$2.27 million. Assuming a population standard deviation gross earnings of \$0.5 million, obtain a 99% confidence interval for the mean gross earnings of all Rolling Stones concerts. Interpret your answer in words.

8.37 Venture-Capital Investments. Refer to Exercise 8.31.

a. Find a 99% confidence interval for μ.
b. Why is the confidence interval you found in part (a) longer than the one in Exercise 8.31?
c. Draw a graph similar to that shown in Fig. 8.5 on page 333 to display both confidence intervals.
d. Which confidence interval yields a more precise estimate of μ? Explain your answer.

8.38 Poverty and Dietary Calcium. Refer to Exercise 8.32.

a. Find a 90% confidence interval for μ.
b. Why is the confidence interval you found in part (a) shorter than the one in Exercise 8.32?
c. Draw a graph similar to that shown in Fig. 8.5 on page 333 to display both confidence intervals.
d. Which confidence interval yields a more precise estimate of μ? Explain your answer.

8.39 Doing Time. The Bureau of Justice Statistics provides information on prison sentences in the document *National Corrections Reporting Program*. A random sample of 20 maximum sentences for murder yielded the data, in months, presented on the WeissStats CD. Use the technology of your choice to do the following.

a. Find a 95% confidence interval for the mean maximum sentence of all murders. Assume a population standard deviation of 30 months.
b. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.
c. Remove the outliers (if any) from the data, and then repeat part (a).
d. Comment on the advisability of using the z-interval procedure on these data.

8.40 Ages of Diabetics. According to the document *All About Diabetes*, found on the Web site of the American Diabetes Association, "...diabetes is a disease in which the body does not produce or properly use insulin, a hormone that is needed to convert sugar, starches, and other food into energy needed for daily life." A random sample of 15 diabetics yielded the data on ages, in years, presented on the WeissStats CD. Use the technology of your choice to do the following.

a. Find a 95% confidence interval for the mean age, μ, of all people with diabetes. Assume that $\sigma = 21.2$ years.
b. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.
c. Remove the outliers (if any) from the data, and then repeat part (a).
d. Comment on the advisability of using the z-interval procedure on these data.

Working with Large Data Sets

8.41 Body Temperature. A study by researchers at the University of Maryland addressed the question of whether the mean body temperature of humans is 98.6°F. The results of the study by P. Mackowiak et al. appeared in the article "A Critical Appraisal of 98.6°F, the Upper Limit of the Normal Body Temperature, and Other Legacies of Carl Reinhold August Wunderlich" (*Journal of the American Medical Association*, Vol. 268, pp. 1578–1580). Among other data, the researchers obtained the body temperatures of 93 healthy humans, as provided on the WeissStats CD. Use the technology of your choice to do the following.

a. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.

9.6 Agriculture Books. The R. R. Bowker Company collects information on the retail prices of books and publishes the data in *The Bowker Annual Library and Book Trade Almanac.* In 2005, the mean retail price of agriculture books was $57.61. A hypothesis test is to be performed to decide whether this year's mean retail price of agriculture books has changed from the 2005 mean.

9.7 Iron Deficiency? Iron is essential to most life forms and to normal human physiology. It is an integral part of many proteins and enzymes that maintain good health. Recommendations for iron are provided in *Dietary Reference Intakes*, developed by the Institute of Medicine of the National Academy of Sciences. The recommended dietary allowance (RDA) of iron for adult females under the age of 51 years is 18 milligrams (mg) per day. A hypothesis test is to be performed to decide whether adult females under the age of 51 years are, on average, getting less than the RDA of 18 mg of iron.

9.8 Early-Onset Dementia. Dementia is the loss of the intellectual and social abilities severe enough to interfere with judgment, behavior, and daily functioning. Alzheimer's disease is the most common type of dementia. In the article "Living with Early Onset Dementia: Exploring the Experience and Developing Evidence-Based Guidelines for Practice" (*Alzheimer's Care Quarterly*, Vol. 5, Issue 2, pp. 111–122), P. Harris and J. Keady explored the experience and struggles of people diagnosed with dementia and their families. A hypothesis test is to be performed to decide whether the mean age at diagnosis of all people with early-onset dementia is less than 55 years old.

9.9 Serving Time. According to the Bureau of Crime Statistics and Research of Australia, as reported on *Lawlink*, the mean length of imprisonment for motor-vehicle-theft offenders in Australia is 16.7 months. You want to perform a hypothesis test to decide whether the mean length of imprisonment for motor-vehicle-theft offenders in Sydney differs from the national mean in Australia.

9.10 Worker Fatigue. A study by M. Chen et al. titled "Heat Stress Evaluation and Worker Fatigue in a Steel Plant" (*American Industrial Hygiene Association*, Vol. 64, pp. 352–359) assessed fatigue in steel-plant workers due to heat stress. Among other things, the researchers monitored the heart rates of a random sample of 29 casting workers. A hypothesis test is to be conducted to decide whether the mean post-work heart rate of casting workers exceeds the normal resting heart rate of 72 beats per minute (bpm).

9.11 Body Temperature. A study by researchers at the University of Maryland addressed the question of whether the mean body temperature of humans is 98.6°F. The results of the study by P. Mackowiak et al. appeared in the article "A Critical Appraisal of 98.6°F, the Upper Limit of the Normal Body Temperature, and Other Legacies of Carl Reinhold August Wunderlich" (*Journal of the American Medical Association*, Vol. 268, pp. 1578–1580). Among other data, the researchers obtained the body temperatures of 93 healthy humans. Suppose that you want to use those data to decide whether the mean body temperature of healthy humans differs from 98.6°F.

9.12 Teacher Salaries. The Educational Resource Service publishes information about wages and salaries in the public schools system in *National Survey of Salaries and Wages in Public Schools*. The mean annual salary of (public) classroom teachers is $49.0 thousand. A hypothesis test is to be performed to decide whether the mean annual salary of classroom teachers in Hawaii is greater than the national mean.

9.13 Cell Phones. The number of cell phone users has increased dramatically since 1987. According to the *Semi-annual Wireless Survey*, published by the Cellular Telecommunications & Internet Association, the mean local monthly bill for cell phone users in the United States was $49.94 in 2007. A hypothesis test is to be performed to determine whether last year's mean local monthly bill for cell phone users has decreased from the 2007 mean of $49.94.

9.14 Suppose that, in a hypothesis test, the null hypothesis is in fact true.
a. Is it possible to make a Type I error? Explain your answer.
b. Is it possible to make a Type II error? Explain your answer.

9.15 Suppose that, in a hypothesis test, the null hypothesis is in fact false.
a. Is it possible to make a Type I error? Explain your answer.
b. Is it possible to make a Type II error? Explain your answer.

9.16 What is the relation between the significance level of a hypothesis test and the probability of making a Type I error?

9.17 Answer true or false and explain your answer: If it is important not to reject a true null hypothesis, the hypothesis test should be performed at a small significance level.

9.18 Answer true or false and explain your answer: For a fixed sample size, decreasing the significance level of a hypothesis test results in an increase in the probability of making a Type II error.

9.19 Identify the two types of incorrect decisions in a hypothesis test. For each incorrect decision, what symbol is used to represent the probability of making that type of error?

9.20 Suppose that a hypothesis test is performed at a small significance level. State the appropriate conclusion in each case by referring to Key Fact 9.2.
a. The null hypothesis is rejected.
b. The null hypothesis is not rejected.

9.21 Toxic Mushrooms? Refer to Exercise 9.5. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision

Now suppose that the results of carrying out the hypothesis test lead to nonrejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean cadmium level in *Boletus pinicola* mushrooms
d. equals the safety limit of 0.5 ppm.
e. exceeds the safety limit of 0.5 ppm.

9.22 Agriculture Books. Refer to Exercise 9.6. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision

Now suppose that the results of carrying out the hypothesis test lead to rejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact this year's mean retail price of agriculture books
d. equals the 2005 mean of $57.61.
e. differs from the 2005 mean of $57.61.

9.23 Iron Deficiency? Refer to Exercise 9.7. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision

Now suppose that the results of carrying out the hypothesis test lead to rejection of the null hypothesis. Classify that conclusion

by error type or as a correct decision if in fact the mean iron intake of all adult females under the age of 51 years
d. equals the RDA of 18 mg per day.
e. is less than the RDA of 18 mg per day.

9.24 Early-Onset Dementia. Refer to Exercise 9.8. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to nonrejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean age at diagnosis of all people with early-onset dementia
d. is 55 years old.
e. is less than 55 years old.

9.25 Serving Time. Refer to Exercise 9.9. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to nonrejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean length of imprisonment for motor-vehicle-theft offenders in Sydney
d. equals the national mean of 16.7 months.
e. differs from the national mean of 16.7 months.

9.26 Worker Fatigue. Refer to Exercise 9.10. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to rejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean post-work heart rate of casting workers
d. equals the normal resting heart rate of 72 bpm.
e. exceeds the normal resting heart rate of 72 bpm.

9.27 Body Temperature. Refer to Exercise 9.11. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to rejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean body temperature of all healthy humans
d. is 98.6°F.
e. is not 98.6°F.

9.28 Teacher Salaries. Refer to Exercise 9.12. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to nonrejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact the mean salary of classroom teachers in Hawaii
d. equals the national mean of $49.0 thousand.
e. exceeds the national mean of $49.0 thousand.

9.29 Cell Phones. Refer to Exercise 9.13. Explain what each of the following would mean.
a. Type I error **b.** Type II error **c.** Correct decision
Now suppose that the results of carrying out the hypothesis test lead to nonrejection of the null hypothesis. Classify that conclusion by error type or as a correct decision if in fact last year's mean local monthly bill for cell phone users
d. equals the 2007 mean of $49.94.
e. is less than the 2007 mean of $49.94.

9.30 Approving Nuclear Reactors. Suppose that you are performing a statistical test to decide whether a nuclear reactor should be approved for use. Further suppose that failing to reject the null hypothesis corresponds to approval. What property would you want the Type II error probability, β, to have?

9.31 Guilty or Innocent? In the U.S. court system, a defendant is assumed innocent until proven guilty. Suppose that you regard a court trial as a hypothesis test with null and alternative hypotheses

$$H_0\text{: Defendant is innocent}$$
$$H_a\text{: Defendant is guilty.}$$

a. Explain the meaning of a Type I error.
b. Explain the meaning of a Type II error.
c. If you were the defendant, would you want α to be large or small? Explain your answer.
d. If you were the prosecuting attorney, would you want β to be large or small? Explain your answer.
e. What are the consequences to the court system if you make $\alpha = 0$? $\beta = 0$?

9.2 Critical-Value Approach to Hypothesis Testing†

With the critical-value approach to hypothesis testing, we choose a "cutoff point" (or cutoff points) based on the significance level of the hypothesis test. The criterion for deciding whether to reject the null hypothesis involves a comparison of the value of the test statistic to the cutoff point(s). Our next example introduces these ideas.

EXAMPLE 9.5 The Critical-Value Approach

Golf Driving Distances Jack tells Jean that his average drive of a golf ball is 275 yards. Jean is skeptical and asks for substantiation. To that end, Jack hits 25 drives. The results, in yards, are shown in Table 9.2.

† Those concentrating on the P-value approach to hypothesis testing can skip this section if so desired.

INSTRUCTIONS 9.1 Steps for generating Output 9.1

MINITAB

1. Store the data from Table 9.10 in a column named CALCIUM
2. Choose **Stat ➤ Basic Statistics ➤ 1-Sample Z...**
3. Select the **Samples in columns** option button
4. Click in the **Samples in columns** text box and specify CALCIUM
5. Click in the **Standard deviation** text box and type 188
6. Check the **Perform hypothesis test** check box
7. Click in the **Hypothesized mean** text box and type 1000
8. Click the **Options...** button
9. Click the arrow button at the right of the **Alternative** drop-down list box and select **less than**
10. Click **OK** twice

EXCEL

1. Store the data from Table 9.10 in a range named CALCIUM
2. Choose **DDXL ➤ Hypothesis Tests**
3. Select **1 Var z Test** from the **Function type** drop-down box
4. Specify CALCIUM in the **Quantitative Variable** text box
5. Click **OK**
6. Click the **Set $\mu 0$ and sd** button
7. Click in the **Hypothesized $\mu 0$** text box and type 1000
8. Click in the **Population std dev** text box and type 188
9. Click **OK**
10. Click the **0.05** button
11. Click the **$\mu < \mu 0$** button
12. Click the **Compute** button

TI-83/84 PLUS

1. Store the data from Table 9.10 in a list named CALCI
2. Press **STAT**, arrow over to **TESTS**, and press **1**
3. Highlight **Data** and press **ENTER**
4. Press the down-arrow key, type 1000 for μ_0, and press **ENTER**
5. Type 188 for σ and press **ENTER**
6. Press **2nd ➤ LIST**
7. Arrow down to CALCI and press **ENTER** three times
8. Highlight $< \mu_0$ and press **ENTER**
9. Press the down-arrow key, highlight **Calculate** or **Draw**, and press **ENTER**

Exercises 9.4

Understanding the Concepts and Skills

9.64 Explain why considering outliers is important when you are conducting a one-mean z-test.

9.65 Each part of this exercise provides a scenario for a hypothesis test for a population mean. Decide whether the z-test is an appropriate method for conducting the hypothesis test. Assume that the population standard deviation is known in each case.

a. Preliminary data analyses reveal that the sample data contain no outliers but that the distribution of the variable under consideration is probably highly skewed. The sample size is 24.

b. Preliminary data analyses reveal that the sample data contain no outliers but that the distribution of the variable under consideration is probably mildly skewed. The sample size is 70.

9.66 Each part of this exercise provides a scenario for a hypothesis test for a population mean. Decide whether the z-test is an appropriate method for conducting the hypothesis test. Assume that the population standard deviation is known in each case.

a. A normal probability plot of the sample data shows no outliers and is quite linear. The sample size is 12.

b. Preliminary data analyses reveal that the sample data contain an outlier. It is determined that the outlier is a legitimate observation and should not be removed. The sample size is 17.

In each of Exercises 9.67–9.72, we have provided a sample mean, sample size, and population standard deviation. In each case, use the one-mean z-test to perform the required hypothesis test at the 5% significance level.

9.67 $\bar{x} = 20, n = 32, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu < 22$

9.68 $\bar{x} = 21, n = 32, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu < 22$

9.69 $\bar{x} = 24, n = 15, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu > 22$

9.70 $\bar{x} = 23, n = 15, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu > 22$

9.71 $\bar{x} = 23, n = 24, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu \neq 22$

9.72 $\bar{x} = 20, n = 24, \sigma = 4, H_0\text{: } \mu = 22, H_a\text{: } \mu \neq 22$

Preliminary data analyses indicate that applying the z-test (Procedure 9.1 on page 380) in Exercises 9.73–9.78 is reasonable.

9.73 Toxic Mushrooms? Cadmium, a heavy metal, is toxic to animals. Mushrooms, however, are able to absorb and accumulate cadmium at high concentrations. The Czech and Slovak governments have set a safety limit for cadmium in dry vegetables at 0.5 part per million (ppm). M. Melgar et al. measured the cadmium levels in a random sample of the edible mushroom *Boletus pinicola* and published the results in the paper "Influence of Some Factors in Toxicity and Accumulation of Cd from Edible Wild Macrofungi in NW Spain" (*Journal of Environmental Science and Health*, Vol. B33(4), pp. 439–455). Here are the data.

0.24	0.59	0.62	0.16	0.77	1.33
0.92	0.19	0.33	0.25	0.59	0.32

At the 5% significance level, do the data provide sufficient evidence to conclude that the mean cadmium level in *Boletus pinicola* mushrooms is greater than the government's recommended limit of 0.5 ppm? Assume that the population standard deviation of cadmium levels in *Boletus pinicola* mushrooms is 0.37 ppm. (*Note:* The sum of the data is 6.31 ppm.)

9.74 Agriculture Books. The R. R. Bowker Company collects information on the retail prices of books and publishes the data in *The Bowker Annual Library and Book Trade Almanac*. In 2005, the mean retail price of agriculture books was \$57.61.

This year's retail prices for 28 randomly selected agriculture books are shown in the following table.

59.54	67.70	57.10	46.11	46.86	62.87	66.40
52.08	37.67	50.47	60.42	38.14	58.21	47.35
50.45	71.03	48.14	66.18	59.36	41.63	53.66
49.95	59.08	58.04	46.65	66.76	50.61	66.68

At the 10% significance level, do the data provide sufficient evidence to conclude that this year's mean retail price of agriculture books has changed from the 2005 mean? Assume that the population standard deviation of prices for this year's agriculture books is \$8.45. (*Note:* The sum of the data is \$1539.14.)

9.75 Iron Deficiency? Iron is essential to most life forms and to normal human physiology. It is an integral part of many proteins and enzymes that maintain good health. Recommendations for iron are provided in *Dietary Reference Intakes*, developed by the Institute of Medicine of the National Academy of Sciences. The recommended dietary allowance (RDA) of iron for adult females under the age of 51 is 18 milligrams (mg) per day. The following iron intakes, in milligrams, were obtained during a 24-hour period for 45 randomly selected adult females under the age of 51.

15.0	18.1	14.4	14.6	10.9	18.1	18.2	18.3	15.0
16.0	12.6	16.6	20.7	19.8	11.6	12.8	15.6	11.0
15.3	9.4	19.5	18.3	14.5	16.6	11.5	16.4	12.5
14.6	11.9	12.5	18.6	13.1	12.1	10.7	17.3	12.4
17.0	6.3	16.8	12.5	16.3	14.7	12.7	16.3	11.5

At the 1% significance level, do the data suggest that adult females under the age of 51 are, on average, getting less than the RDA of 18 mg of iron? Assume that the population standard deviation is 4.2 mg. (*Note:* $\bar{x} = 14.68$ mg.)

9.76 Early-Onset Dementia. Dementia is the loss of the intellectual and social abilities severe enough to interfere with judgment, behavior, and daily functioning. Alzheimer's disease is the most common type of dementia. In the article "Living with Early Onset Dementia: Exploring the Experience and Developing Evidence-Based Guidelines for Practice" (*Alzheimer's Care Quarterly*, Vol. 5, Issue 2, pp. 111–122), P. Harris and J. Keady explored the experience and struggles of people diagnosed with dementia and their families. A simple random sample of 21 people with early-onset dementia gave the following data on age at diagnosis, in years.

60	58	52	58	59	58	51
61	54	59	55	53	44	46
47	42	56	57	49	41	43

At the 1% significance level, do the data provide sufficient evidence to conclude that the mean age at diagnosis of all people with early-onset dementia is less than 55 years old? Assume that the population standard deviation is 6.8 years. (*Note:* $\bar{x} = 52.5$ years.)

9.77 Serving Time. According to the Bureau of Crime Statistics and Research of Australia, as reported on *Lawlink*, the mean length of imprisonment for motor-vehicle-theft offenders in Australia is 16.7 months. One hundred randomly selected motor-vehicle-theft offenders in Sydney, Australia, had a mean length of imprisonment of 17.8 months. At the 5% significance level, do the data provide sufficient evidence to conclude that the mean length of imprisonment for motor-vehicle-theft offenders in Sydney differs from the national mean in Australia? Assume that the population standard deviation of the lengths of imprisonment for motor-vehicle-theft offenders in Sydney is 6.0 months.

9.78 Worker Fatigue. A study by M. Chen et al. titled "Heat Stress Evaluation and Worker Fatigue in a Steel Plant" (*American Industrial Hygiene Association*, Vol. 64, pp. 352–359) assessed fatigue in steel-plant workers due to heat stress. A random sample of 29 casting workers had a mean post-work heart rate of 78.3 beats per minute (bpm). At the 5% significance level, do the data provide sufficient evidence to conclude that the mean post-work heart rate for casting workers exceeds the normal resting heart rate of 72 bpm? Assume that the population standard deviation of post-work heart rates for casting workers is 11.2 bpm.

9.79 Job Gains and Losses. In the article "Business Employment Dynamics: New Data on Gross Job Gains and Losses" (*Monthly Labor Review*, Vol. 127, Issue 4, pp. 29–42), J. Spletzer et al. examined gross job gains and losses as a percentage of the average of previous and current employment figures. A simple random sample of 20 quarters provided the net percentage gains (losses are negative gains) for jobs as presented on the WeissStats CD. Use the technology of your choice to do the following.

a. Decide whether, on average, the net percentage gain for jobs exceeds 0.2. Assume a population standard deviation of 0.42. Apply the one-mean z-test with a 5% significance level.

b. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.

c. Remove the outliers (if any) from the data and then repeat part (a).

d. Comment on the advisability of using the z-test here.

9.80 Hotels and Motels. The daily charges, in dollars, for a sample of 15 hotels and motels operating in South Carolina are provided on the WeissStats CD. The data were found in the report *South Carolina Statistical Abstract*, sponsored by the South Carolina Budget and Control Board.

a. Use the one-mean z-test to decide, at the 5% significance level, whether the data provide sufficient evidence to conclude that the mean daily charge for hotels and motels operating in South Carolina is less than \$75. Assume a population standard deviation of \$22.40.

b. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.

c. Remove the outliers (if any) from the data and then repeat part (a).

d. Comment on the advisability of using the z-test here.

Working with Large Data Sets

9.81 Body Temperature. A study by researchers at the University of Maryland addressed the question of whether the mean body temperature of humans is 98.6°F. The results of the study by P. Mackowiak et al. appeared in the article "A Critical Appraisal of 98.6°F, the Upper Limit of the Normal Body Temperature, and Other Legacies of Carl Reinhold August Wunderlich" (*Journal of the American Medical Association*, Vol. 268, pp. 1578–1580). Among other data, the researchers obtained the body temperatures of 93 healthy humans, which we provide on the WeissStats CD. Use the technology of your choice to do the following.

a. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.
b. Based on your results from part (a), can you reasonably apply the one-mean z-test to the data? Explain your reasoning.
c. At the 1% significance level, do the data provide sufficient evidence to conclude that the mean body temperature of healthy humans differs from 98.6°F? Assume that $\sigma = 0.63$°F.

9.82 Teacher Salaries. The Educational Resource Service publishes information about wages and salaries in the public schools system in *National Survey of Salaries and Wages in Public Schools*. The mean annual salary of (public) classroom teachers is \$49.0 thousand. A random sample of 90 classroom teachers in Hawaii yielded the annual salaries, in thousands of dollars, presented on the WeissStats CD. Use the technology of your choice to do the following.

a. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.
b. Based on your results from part (a), can you reasonably apply the one-mean z-test to the data? Explain your reasoning.
c. At the 5% significance level, do the data provide sufficient evidence to conclude that the mean annual salary of classroom teachers in Hawaii is greater than the national mean? Assume that the standard deviation of annual salaries for all classroom teachers in Hawaii is \$9.2 thousand.

9.83 Cell Phones. The number of cell phone users has increased dramatically since 1987. According to the *Semi-annual Wireless Survey*, published by the Cellular Telecommunications & Internet Association, the mean local monthly bill for cell phone users in the United States was \$49.94 in 2007. Last year's local monthly bills, in dollars, for a random sample of 75 cell phone users are given on the WeissStats CD. Use the technology of your choice to do the following.

a. Obtain a normal probability plot, boxplot, histogram, and stem-and-leaf diagram of the data.
b. At the 5% significance level, do the data provide sufficient evidence to conclude that last year's mean local monthly bill for cell phone users decreased from the 2007 mean of \$49.94? Assume that the population standard deviation of last year's local monthly bills for cell phone users is \$25.
c. Remove the two outliers from the data and repeat parts (a) and (b).
d. State your conclusions regarding the hypothesis test.

Extending the Concepts and Skills

9.84 Class Project: Quality Assurance. This exercise can be done individually or, better yet, as a class project. For the pretzel-packaging hypothesis test in Example 9.1 on page 360, the null and alternative hypotheses are, respectively,

$$H_0: \mu = 454 \text{ g (machine is working properly)}$$
$$H_a: \mu \neq 454 \text{ g (machine is not working properly)},$$

where μ is the mean net weight of all bags of pretzels packaged. The net weights are normally distributed with a standard deviation of 7.8 g.

a. Assuming that the null hypothesis is true, simulate 100 samples of 25 net weights each.
b. Suppose that the hypothesis test is performed at the 5% significance level. Of the 100 samples obtained in part (a), roughly how many would you expect to lead to rejection of the null hypothesis? Explain your answer.
c. Of the 100 samples obtained in part (a), determine the number that lead to rejection of the null hypothesis.
d. Compare your answers from parts (b) and (c), and comment on any observed difference.

9.85 Two-Tailed Hypothesis Tests and CIs. As we mentioned on page 386, the following relationship holds between hypothesis tests and confidence intervals for one-mean z-procedures: For a two-tailed hypothesis test at the significance level α, the null hypothesis H_0: $\mu = \mu_0$ will be rejected in favor of the alternative hypothesis H_a: $\mu \neq \mu_0$ if and only if μ_0 lies outside the $(1 - \alpha)$-level confidence interval for μ. In each case, illustrate the preceding relationship by obtaining the appropriate one-mean z-interval (Procedure 8.1 on page 330) and comparing the result to the conclusion of the hypothesis test in the specified exercise.

a. Exercise 9.74
b. Exercise 9.77

9.86 Left-Tailed Hypothesis Tests and CIs. In Exercise 8.47 on page 337, we introduced one-sided one-mean z-intervals. The following relationship holds between hypothesis tests and confidence intervals for one-mean z-procedures: For a left-tailed hypothesis test at the significance level α, the null hypothesis H_0: $\mu = \mu_0$ will be rejected in favor of the alternative hypothesis H_a: $\mu < \mu_0$ if and only if μ_0 is greater than the $(1 - \alpha)$-level upper confidence bound for μ. In each case, illustrate the preceding relationship by obtaining the appropriate upper confidence bound and comparing the result to the conclusion of the hypothesis test in the specified exercise.

a. Exercise 9.75
b. Exercise 9.76

9.87 Right-Tailed Hypothesis Tests and CIs. In Exercise 8.47 on page 337, we introduced one-sided one-mean z-intervals. The following relationship holds between hypothesis tests and confidence intervals for one-mean z-procedures: For a right-tailed hypothesis test at the significance level α, the null hypothesis H_0: $\mu = \mu_0$ will be rejected in favor of the alternative hypothesis H_a: $\mu > \mu_0$ if and only if μ_0 is less than the $(1 - \alpha)$-level lower confidence bound for μ. In each case, illustrate the preceding relationship by obtaining the appropriate lower confidence bound and comparing the result to the conclusion of the hypothesis test in the specified exercise.

a. Exercise 9.73
b. Exercise 9.78

9.5 Hypothesis Tests for One Population Mean When σ Is Unknown

In Section 9.4, you learned how to perform a hypothesis test for one population mean when the population standard deviation, σ, is known. However, as we have mentioned, the population standard deviation is usually not known.

Confidence and Precision

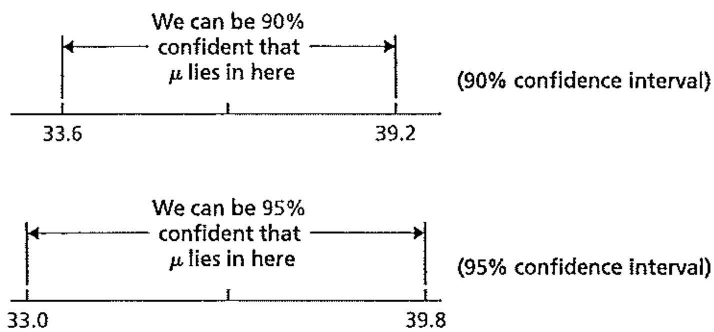
The confidence level of a confidence interval for a population mean, μ, signifies the confidence we have that μ actually lies in that interval. The length of the confidence interval indicates the precision of the estimate, or how well we have "pinned down" μ. Long confidence intervals indicate poor precision; short confidence intervals indicate good precision.

How does the confidence level affect the length of the confidence interval? To answer this question, let's return to Example 8.4, where we found a 95% confidence interval for the mean age, μ, of all people in the civilian labor force. The confidence level there is 0.95, and the confidence interval is from 33.0 to 39.8 years. If we change the confidence level from 0.95 to, say, 0.90, then $z_{\alpha/2}$ changes from $z_{0.05/2} = z_{0.025} = 1.96$ to $z_{0.10/2} = z_{0.05} = 1.645$. The resulting confidence interval, using the same sample data (Table 8.3), is from

$$36.4 - 1.645 \cdot \frac{12.1}{\sqrt{50}} \quad \text{to} \quad 36.4 + 1.645 \cdot \frac{12.1}{\sqrt{50}},$$

or from 33.6 to 39.2 years. Figure 8.5 shows both the 90% and 95% confidence intervals.

FIGURE 8.5
90% and 95% confidence intervals for μ, using the data in Table 8.3



Thus, decreasing the confidence level decreases the length of the confidence interval, and vice versa. So, if we can settle for less confidence that μ lies in our confidence interval, we get a shorter interval. However, if we want more confidence that μ lies in our confidence interval, we must settle for a greater interval.

KEY FACT 8.3 **Confidence and Precision**

For a fixed sample size, decreasing the confidence level improves the precision, and vice versa.

THE TECHNOLOGY CENTER

Most statistical technologies have programs that automatically perform the one-mean z-interval procedure. In this subsection, we present output and step-by-step instructions for such programs.

EXAMPLE 8.5 Using Technology to Obtain a One-Mean z-Interval

The Civilian Labor Force Table 8.3 on page 331 displays the ages of 50 randomly selected people in the civilian labor force. Use Minitab, Excel, or the TI-83/84 Plus to determine a 95% confidence interval for the mean age, μ, of all people in the civilian labor force. Assume that the population standard deviation of the ages is 12.1 years.