EXERCISES Section 7.1 (1–11)

1. Consider a normal population distribution with the value of σ known.
   a. What is the confidence level for the interval $\bar{x} \pm 2.81\sigma/\sqrt{n}$?
   b. What is the confidence level for the interval $\bar{x} \pm 1.44\sigma/\sqrt{n}$?
   c. What value of $z_{\alpha/2}$ in the CI formula (7.5) results in a confidence level of 99.7%?
   d. Answer the question posed in part (c) for a confidence level of 75%.

3. Suppose that a random sample of 50 bottles of a particular brand of cough syrup is selected and the alcohol content of each bottle is determined. Let μ denote the average alcohol content for the population of all bottles of the brand under study. Suppose that the resulting 95% confidence interval is (7.8, 9.4).
   a. Would a 90% confidence interval calculated from this same sample have been narrower or wider than the given interval? Explain your reasoning.
   b. Consider the following statement: There is a 95% chance that μ is between 7.8 and 9.4. Is this statement correct? Why or why not?
   c. Consider the following statement: We can be highly confident that 95% of all bottles of this type of cough syrup have an alcohol content that is between 7.8 and 9.4. Is this statement correct? Why or why not?
   d. Consider the following statement: If the process of selecting a sample of size 50 and then computing the corresponding 95% interval is repeated 100 times, 95 of the resulting intervals will include μ. Is this statement correct? Why or why not?

5. Assume that the helium porosity (in percentage) of coal samples taken from any particular seam is normally distributed with true standard deviation .75.
   a. Compute a 95% CI for the true average porosity of a certain seam if the average porosity for 20 specimens from the seam was 4.85.
   b. Compute a 98% CI for true average porosity of another seam based on 16 specimens with a sample average porosity of 4.56.
   c. How large a sample size is necessary if the width of the 95% interval is to be .40?
   d. What sample size is necessary to estimate true average porosity to within .2 with 99% confidence?

EXERCISES Section 7.2 (12–27)

13. The article "Gas Cooking, Kitchen Ventilation, and Exposure to Combustion Products" (*Indoor Air*, 2006: 65–73) reported that for a sample of 50 kitchens with gas cooking appliances monitored during a one-week period, the sample mean CO_2 level (ppm) was 654.16, and the sample standard deviation was 164.43.
    a. Calculate and interpret a 95% (two-sided) confidence interval for true average CO_2 level in the population of all homes from which the sample was selected.
    b. Suppose the investigators had made a rough guess of 175 for the value of s before collecting data. What sample size would be necessary to obtain an interval width of 50 ppm for a confidence level of 95%?

17. Exercise 1.13 gave a sample of ultimate tensile strength observations (ksi). Use the accompanying descriptive statistics output from MINITAB to calculate a 99% lower confidence bound for true average ultimate tensile strength, and interpret the result.

N	Mean	Median	TrMean	StDev	SE Mean
153	135.39	135.40	135.41	4.59	0.37
Minimum	Maximum	Q1	Q3		
122.20	147.70	132.95	138.25		

19. The article "Limited Yield Estimation for Visual Defect Sources" (*IEEE Trans. on Semiconductor Manuf.*, 1997: 17–23) reported that, in a study of a particular wafer inspection process, 356 dies were examined by an inspection probe and 201 of these passed the probe. Assuming a stable process, calculate a 95% (two-sided) confidence interval for the proportion of all dies that pass the probe.

23. The article "An Evaluation of Football Helmets Under Impact Conditions" (*Amer. J. Sports Medicine*, 1984: 233–237) reports that when each football helmet in a random sample of 37 suspension-type helmets was subjected to a certain impact test, 24 showed damage. Let p denote the proportion of all helmets of this type that would show damage when tested in the prescribed manner.

a. Calculate a 99% CI for p.

b. What sample size would be required for the width of a 99% CI to be at most .10, irrespective of $\hat{p}$?

EXERCISES Section 7.3 (28–41)

29. Determine the t critical value that will capture the desired t curve area in each of the following cases:

a. Central area = .95, df = 10

b. Central area = .95, df = 20

c. Central area = .99, df = 20

d. Central area = .99, df = 50

e. Upper-tail area = .01, df = 25

f. Lower-tail area = .025, df = 5

30. Determine the t critical value for a two-sided confidence interval in each of the following situations:

a. Confidence level = 95%, df = 10

b. Confidence level = 95%, df = 15

c. Confidence level = 99%, df = 15

d. Confidence level = 99%, $n = 5$

e. Confidence level = 98%, df = 24

f. Confidence level = 99%, $n = 38$

33. The article "Measuring and Understanding the Aging of Kraft Insulating Paper in Power Transformers" (*IEEE Electrical Insul. Mag.,* 1996: 28–34) contained the following observations on degree of polymerization for paper specimens for which viscosity times concentration fell in a certain middle range:

418	421	421	422	425	427	431
434	437	439	446	447	448	453
454	463	465				

a. Construct a boxplot of the data and comment on any interesting features.

b. Is it plausible that the given sample observations were selected from a normal distribution?

c. Calculate a two-sided 95% confidence interval for true average degree of polymerization (as did the authors of the article). Does the interval suggest that 440 is a plausible value for true average degree of polymerization? What about 450?

35. Silicone implant augmentation rhinoplasty is used to correct congenital nose deformities. The success of the procedure depends on various biomechanical properties of the human nasal periosteum and fascia. The article "Biomechanics in Augmentation Rhinoplasty" (*J. of Med. Engr. and Tech.,* 2005: 14–17) reported that for a sample of 15 (newly deceased) adults, the mean failure strain (%) was 25.0, and the standard deviation was 3.5.

a. Assuming a normal distribution for failure strain, estimate true average strain in a way that conveys information about precision and reliability.

b. Predict the strain for a single adult in a way that conveys information about precision and reliability. How does the prediction compare to the estimate calculated in part (a)?

37. A study of the ability of individuals to walk in a straight line ("Can We Really Walk Straight?" *Amer. J. of Physical Anthro.,* 1992: 19–27) reported the accompanying data on cadence (strides per second) for a sample of $n = 20$ randomly selected healthy men.

.95	.85	.92	.95	.93	.86	1.00	.92	.85	.81
.78	.93	.93	1.05	.93	1.06	1.06	.96	.81	.96

A normal probability plot gives substantial support to the assumption that the population distribution of cadence is approximately normal. A descriptive summary of the data from MINITAB follows:

```
Variable N  Mean   Median  TrMean  StDev   SEMean
cadence 20 0.9255 0.9300  0.9261  0.0809  0.0181
Variable    Min    Max     Q1      Q3
cadence    0.7800 1.0600  0.8525  0.9600
```

a. Calculate and interpret a 95% confidence interval for population mean cadence.

b. Calculate and interpret a 95% prediction interval for the cadence of a single individual randomly selected from this population.

c. Calculate an interval that includes at least 99% of the cadences in the population distribution using a confidence level of 95%.

EXERCISES Section 8.1 (1–14)

1. For each of the following assertions, state whether it is a legitimate statistical hypothesis and why:
   a. $H: \sigma > 100$ b. $H: \tilde{x} = 45$
   c. $H: s \le .20$ d. $H: \sigma_1/\sigma_2 < 1$
   e. $H: \bar{X} - \bar{Y} = 5$
   f. $H: \lambda \le .01$, where λ is the parameter of an exponential distribution used to model component lifetime

3. To determine whether the pipe welds in a nuclear power plant meet specifications, a random sample of welds is selected, and tests are conducted on each weld in the sample. Weld strength is measured as the force required to break the weld. Suppose the specifications state that mean strength of welds should exceed 100 lb/in^2; the inspection team decides to test H_0: $\mu = 100$ versus H_a: $\mu > 100$. Explain why it might be preferable to use this H_a rather than $\mu < 100$.

5. Before agreeing to purchase a large order of polyethylene sheaths for a particular type of high-pressure oil-filled submarine power cable, a company wants to see conclusive evidence that the true standard deviation of sheath thickness is less than .05 mm. What hypotheses should be tested, and why? In this context, what are the type I and type II errors?

7. Water samples are taken from water used for cooling as it is being discharged from a power plant into a river. It has been determined that as long as the mean temperature of the discharged water is at most 150°F, there will be no negative effects on the river's ecosystem. To investigate whether the plant is in compliance with regulations that prohibit a mean discharge-water temperature above 150°, 50 water samples will be taken at randomly selected times, and the temperature of each sample recorded. The resulting data will be used to test the hypotheses H_0: $\mu = 150°$ versus H_a: $\mu > 150°$. In the context of this situation, describe type I and type II errors. Which type of error would you consider more serious? Explain.

EXERCISES Section 8.2 (15–34)

17. Answer the following questions for the tire problem in Example 8.7.
    a. If $\bar{x} = 30{,}960$ and a level $\alpha = .01$ test is used, what is the decision?
    b. If a level .01 test is used, what is $\beta(30{,}500)$?
    c. If a level .01 test is used and it is also required that $\beta(30{,}500) = .05$, what sample size n is necessary?
    d. If $\bar{x} = 30{,}960$, what is the smallest α at which H_0 can be rejected (based on $n = 16$)?

19. The melting point of each of 16 samples of a certain brand of hydrogenated vegetable oil was determined, resulting in $\bar{x} = 94.32$. Assume that the distribution of melting point is normal with $\sigma = 1.20$.
    a. Test H_0: $\mu = 95$ versus H_a: $\mu \ne 95$ using a two-tailed level .01 test.
    b. If a level .01 test is used, what is $\beta(94)$, the probability of a type II error when $\mu = 94$?
    c. What value of n is necessary to ensure that $\beta(94) = .1$ when $\alpha = .01$?

21. The true average diameter of ball bearings of a certain type is supposed to be .5 in. A one-sample t test will be carried out to see whether this is the case. What conclusion is appropriate in each of the following situations?
   a. $n = 13, t = 1.6, \alpha = .05$
   b. $n = 13, t = -1.6, \alpha = .05$
   c. $n = 25, t = -2.6, \alpha = .01$
   d. $n = 25, t = -3.9$

23. Exercise 36 in Chapter 1 gave $n = 26$ observations on escape time (sec) for oil workers in a simulated exercise, from which the sample mean and sample standard deviation are 370.69 and 24.36, respectively. Suppose the investigators had believed a priori that true average escape time would be at most 6 min. Does the data contradict this prior belief? Assuming normality, test the appropriate hypotheses using a significance level of .05.

25. The desired percentage of SiO_2 in a certain type of aluminous cement is 5.5. To test whether the true average percentage is 5.5 for a particular production facility, 16 independently obtained samples are analyzed. Suppose that the percentage of SiO_2 in a sample is normally distributed with $\sigma = .3$ and that $\bar{x} = 5.25$.
   a. Does this indicate conclusively that the true average percentage differs from 5.5? Carry out the analysis using the sequence of steps suggested in the text.
   b. If the true average percentage is $\mu = 5.6$ and a level $\alpha = .01$ test based on $n = 16$ is used, what is the probability of detecting this departure from H_0?
   c. What value of n is required to satisfy $\alpha = .01$ and $\beta(5.6) = .01$?

EXERCISES Section 8.4 (45–60)

45. For which of the given P-values would the null hypothesis be rejected when performing a level .05 test?
   a. .001 b. .021 c. .078
   d. .047 e. .148

47. Let μ denote the mean reaction time to a certain stimulus. For a large-sample z test of H_0: $\mu = 5$ versus H_a: $\mu > 5$, find the P-value associated with each of the given values of the z test statistic.
   a. 1.42 b. .90 c. 1.96 d. 2.48 e. $-.11$

51. Let μ denote true average serum receptor concentration for all pregnant women. The average for all women is known to be 5.63. The article "Serum Transferrin Receptor for the Detection of Iron Deficiency in Pregnancy" (*Amer. J. Clinical Nutr.*, 1991: 1077–1081) reports that P-value $> .10$ for a test of H_0: $\mu = 5.63$ versus H_a: $\mu \neq 5.63$ based on $n = 176$ pregnant women. Using a significance level of .01, what would you conclude?

53. An aspirin manufacturer fills bottles by weight rather than by count. Since each bottle should contain 100 tablets, the average weight per tablet should be 5 grains. Each of 100 tablets taken from a very large lot is weighed, resulting in a sample average weight per tablet of 4.87 grains and a sample standard deviation of .35 grain. Does this information provide strong evidence for concluding that the company is not filling its bottles as advertised? Test the appropriate hypotheses using $\alpha = .01$ by first computing the P-value and then comparing it to the specified significance level.

EXERCISES Section 8.3 (35–44)

35. State DMV records indicate that of all vehicles undergoing emissions testing during the previous year, 70% passed on the first try. A random sample of 200 cars tested in a particular county during the current year yields 124 that passed on the initial test. Does this suggest that the true proportion for this county during the current year differs from the previous statewide proportion? Test the relevant hypotheses using $\alpha = .05$.

37. A random sample of 150 recent donations at a certain blood bank reveals that 82 were type A blood. Does this suggest that the actual percentage of type A donations differs from 40%, the percentage of the population having type A blood? Carry out a test of the appropriate hypotheses using a significance level of .01. Would your conclusion have been different if a significance level of .05 had been used?

39. A university library ordinarily has a complete shelf inventory done once every year. Because of new shelving rules instituted the previous year, the head librarian believes it may be possible to save money by postponing the inventory. The librarian decides to select at random 1000 books from the library's collection and have them searched in a preliminary manner. If evidence indicates strongly that the true proportion of misshelved or unlocatable books is less than .02, then the inventory will be postponed.
   a. Among the 1000 books searched, 15 were misshelved or unlocatable. Test the relevant hypotheses and advise the librarian what to do (use $\alpha = .05$).
   b. If the true proportion of misshelved and lost books is actually .01, what is the probability that the inventory will be (unnecessarily) taken?
   c. If the true proportion is .05, what is the probability that the inventory will be postponed?

EXERCISES Section 9.1 (1–16)

1. An article in the November 1983 *Consumer Reports* compared various types of batteries. The average lifetimes of Duracell Alkaline AA batteries and Eveready Energizer Alkaline AA batteries were given as 4.1 hours and 4.5 hours, respectively. Suppose these are the population average lifetimes.
   a. Let $\overline{X}$ be the sample average lifetime of 100 Duracell batteries and $\overline{Y}$ be the sample average lifetime of 100 Eveready batteries. What is the mean value of $\overline{X} - \overline{Y}$ (i.e., where is the distribution of $\overline{X} - \overline{Y}$ centered)? How does your answer depend on the specified sample sizes?
   b. Suppose the population standard deviations of lifetime are 1.8 hours for Duracell batteries and 2.0 hours for Eveready batteries. With the sample sizes given in part (a), what is the variance of the statistic $\overline{X} - \overline{Y}$, and what is its standard deviation?
   c. For the sample sizes given in part (a), draw a picture of the approximate distribution curve of $\overline{X} - \overline{Y}$ (include a measurement scale on the horizontal axis). Would the shape of the curve necessarily be the same for sample sizes of 10 batteries of each type? Explain.

21. Quantitative noninvasive techniques are needed for routinely assessing symptoms of peripheral neuropathies, such as carpal tunnel syndrome (CTS). The article "A Gap Detection Tactility Test for Sensory Deficits Associated with Carpal Tunnel Syndrome" (*Ergonomics,* 1995: 2588–2601) reported on a test that involved sensing a tiny gap in an otherwise smooth surface by probing with a finger; this functionally resembles many work-related tactile activities, such as detecting scratches or surface defects. When finger probing was not allowed, the sample average gap detection threshold for $m = 8$ normal subjects was 1.71 mm, and the sample standard deviation was .53; for $n = 10$ CTS subjects, the sample mean and sample standard deviation were 2.53 and .87, respectively. Does this data suggest that the true average gap detection threshold for CTS subjects exceeds that for normal subjects? State and test the relevant hypotheses using a significance level of .01.

23. Fusible interlinings are being used with increasing frequency to support outer fabrics and improve the shape and drape of various pieces of clothing. The article "Compatibility of Outer and Fusible Interlining Fabrics in Tailored Garments" (*Textile Res. J.,* 1997: 137–142) gave the accompanying data on extensibility (%) at 100 gm/cm for both high-quality fabric (H) and poor-quality fabric (P) specimens.

H	1.2	.9	.7	1.0	1.7	1.7	1.1	.9	1.7
	1.9	1.3	2.1	1.6	1.8	1.4	1.3	1.9	1.6
	.8	2.0	1.7	1.6	2.3	2.0			
P	1.6	1.5	1.1	2.1	1.5	1.3	1.0	2.6	

a. Construct normal probability plots to verify the plausibility of both samples having been selected from normal population distributions.

b. Construct a comparative boxplot. Does it suggest that there is a difference between true average extensibility for high-quality fabric specimens and that for poor-quality specimens?

c. The sample mean and standard deviation for the high-quality sample are 1.508 and .444, respectively, and those for the poor-quality sample are 1.588 and .530. Use the two-sample t test to decide whether true average extensibility differs for the two types of fabric.

25. Low-back pain (LBP) is a serious health problem in many industrial settings. The article "Isodynamic Evaluation of Trunk Muscles and Low-Back Pain Among Workers in a Steel Factory" (*Ergonomics,* 1995: 2107–2117) reported the accompanying summary data on lateral range of motion (degrees) for a sample of workers without a history of LBP and another sample with a history of this malady.

Condition	Sample Size	Sample Mean	Sample SD
No LBP	28	91.5	5.5
LBP	31	88.3	7.8

Calculate a 90% confidence interval for the difference between population mean extent of lateral motion for the two conditions. Does the interval suggest that population mean lateral motion differs for the two conditions? Is the message different if a confidence level of 95% is used?

27. Tennis elbow is thought to be aggravated by the impact experienced when hitting the ball. The article "Forces on the Hand in the Tennis One-Handed Backhand" (*Intl. J. of Sport Biomechanics,* 1991: 282–292) reported the force (N) on the hand just after impact on a one-handed backhand drive for six advanced players and for eight intermediate players.

Type of Player	Sample Size	Sample Mean	Sample SD
1. Advanced	6	40.3	11.3
2. Intermediate	8	21.4	8.3

In their analysis of the data, the authors assumed that both force distributions were normal. Calculate a 95% CI for the difference between true average force for advanced players (μ_1) and true average force for intermediate players (μ_2). Does your interval provide compelling evidence for concluding that the two μs are different? Would you have reached the same conclusion by calculating a CI for $\mu_2 - \mu_1$ (i.e., by reversing the 1 and 2 labels on the two types of players)? Explain.

EXERCISES Section 9.3 (36–46)

39. Scientists and engineers frequently wish to compare two different techniques for measuring or determining the value of a variable. In such situations, interest centers on testing whether the mean difference in measurements is zero. The article "Evaluation of the Deuterium Dilution Technique Against the Test Weighing Procedure for the Determination of Breast Milk Intake" (*Amer. J. Clinical Nutr.*, 1983: 996–1003) reports the accompanying data on amount of milk ingested by each of 14 randomly selected infants.

	Infant													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Isotopic method	1509	1418	1561	1556	2169	1760	1098	1198	1479	1281	1414	1954	2174	2058
Test-weighing method	1498	1254	1336	1565	2000	1318	1410	1129	1342	1124	1468	1604	1722	1518
Difference	11	164	225	−9	169	442	−312	69	137	157	−54	350	452	540

a. Is it plausible that the population distribution of differences is normal?

b. Does it appear that the true average difference between intake values measured by the two methods is something other than zero? Determine the *P*-value of the test, and use it to reach a conclusion at significance level .05.

41. In an experiment designed to study the effects of illumination level on task performance ("Performance of Complex Tasks Under Different Levels of Illumination," *J. Illuminating Eng.*, 1976: 235–242), subjects were required to insert a fine-tipped probe into the eyeholes of ten needles in rapid succession both for a low light level with a black background and a higher level with a white background. Each data value is the time (sec) required to complete the task.

	Subject								
	1	2	3	4	5	6	7	8	9
Black	25.85	28.84	32.05	25.74	20.89	41.05	25.01	24.96	27.47
White	18.23	20.84	22.96	19.68	19.50	24.98	16.61	16.07	24.59

Does the data indicate that the higher level of illumination yields a decrease of more than 5 sec in true average task completion time? Test the appropriate hypotheses using the *P*-value approach.