

## AE Additional Exercises

- Black Bark, a Colorado based company, makes wood burning stoves. They are interested in comparing two designs to determine which design will produce a stove with a greater average burning time. Several prototypes of each design are tested and the time required to burn 15 pounds of wood was measured (the burning time is measured in hours). The results of the test are as follows.

Burning Time for Stoves (Hours)			
	$n$	$\bar{x}$	$\sigma$
Stove A	32	9.35	0.50
Stove B	35	9.75	0.75

Is there sufficient evidence at  $\alpha = 0.05$  for Black Bark to conclude that the mean burning time for Stove B is greater than for Stove A?

- In each of the following experimental situations give the appropriate null and alternative hypotheses to be tested. Define all terms that appear in these hypotheses.
  - Independent random samples of 50 male nurses and 50 female nurses are selected from the hospitals in a Southern state. Each nurse is asked whether he or she is satisfied with the working conditions in the hospital. It is of interest to see if there is a difference between male nurses and female nurses on satisfaction with working conditions.
  - A group of 45 high school seniors take the SAT reasoning test both before and after a 3-month training course, which is designed to improve SAT scores. We wish to determine if the training course is effective.
  - Starting salaries are determined for 40 female and 40 male electrical engineers. It is of interest to determine if female electrical engineers tend to have higher starting salaries than their male counterparts.
  - Random and independent samples of younger ( $\text{age} \leq 30$ ) and older ( $\text{age} > 30$ ) automobile drivers are chosen and asked whether they have had a speeding ticket in the past 12 months. It is intended to show that younger drivers are more likely than older drivers to have had a speeding ticket in the past 12 months.
  - Do women have a shorter reaction time than men when exposed to a certain stimulus? Random and independent samples of 10 men and 10 women are included in an experiment that measures reaction time to the stimulus.
- A nutritionist is interested in determining the decrease in cholesterol level which a person can achieve by following a particular diet that is low in fat and high in fiber. Seven subjects are randomly selected to try the diet for six months, and their cholesterol levels are measured both before and after the diet. The results of the study are as follows.

Cholesterol Levels							
Subject	1	2	3	4	5	6	7
Before Diet	155	170	145	200	162	180	160
After Diet	152	168	148	195	162	178	157

- Is a paired design appropriate for the above experiment? Explain.
- What assumption must be made in order to perform the test of hypothesis?
- Do the data appear to satisfy the assumption described in part **b.**? Why or why not?
- Can the nutritionist conclude that there is a significant decrease in average cholesterol level when the diet is used? Use  $\alpha = 0.01$ .

4. The design group for a monofilament cord manufacturer is testing two possible compositions of the cord for tensile strength. Composition A is more difficult to manufacture than Composition B, so the design group has decided that it will recommend Composition A only if the mean tensile strength for Composition A is shown to be significantly greater than the mean tensile strength for Composition B. Several monofilament cords of each sample are tested and the tensile strengths are measured in pounds per square inch. Assume that the population variances are approximately equal.

Tensile Strength (Pounds per Square Inch)			
	$n$	$\bar{x}$	$s$
Composition A	20	52,907	2575
Composition B	20	50,219	1210

- What assumptions must be made in order to perform the hypothesis test?
  - Will the design group recommend Composition A or Composition B for the monofilament cord at  $\alpha = 0.10$ ?
5. Consider Example 11.3.1. If you were to perform a two-sample  $t$ -test, you would find that you would fail to reject the null hypothesis and conclude that there is no difference in average daily sales between the two restaurants. Of course, it would be difficult to believe such a test given that if we examine the data in Table 11.3.2, we see that each of the daily sales figures from Restaurant 2 is more than that from Restaurant 1. From this observation, it is clear that the average daily sales between the restaurants are different. Why, then, would the  $t$ -test be unable to detect this difference? The answer: **an independent samples  $t$ -test is not a valid procedure to use with paired data.** The  $t$ -test is inappropriate because the assumption of independent samples is invalid since the dependence between restaurants is a function of the days. Perform the two-sample  $t$ -test to verify that the independent samples test would lead the owner to fail to reject the null hypothesis and conclude that there is not a significant difference between average daily sales. The data from Table 11.3.2 are replicated below for your convenience. Use  $\alpha = 0.01$ .

Daily Food Sales for Two Restaurants (\$)			
Day	Restaurant 1	Restaurant 2	Difference = Restaurant 1 – Restaurant 2
1	5828	7894	-2066
2	9836	11,573	-1737
3	3984	5319	-1335
4	5845	6389	-544
5	5210	6055	-845
6	9668	10,631	-963
7	6768	7866	-1098
8	6726	7976	-1250
9	4399	5652	-1253
10	6692	8083	-1391

6. Two independent random samples have been selected, 100 from Population 1 and 150 from Population 2. The sample mean from the first population is 1025 with a population standard deviation of 10. For the second sample, the mean is 1039 with a population standard deviation of 12.
- Test that there is no difference between the groups using  $\alpha = 0.01$ .
  - Construct a 95% confidence interval for the true mean difference between Population 1 and Population 2.

7. The manufacturer of Brand 1 cigarettes claims that his cigarettes are no more harmful to health than Brand 2 (filtered) cigarettes. Assuming harmfulness is to be associated with nicotine content, the FDA took random samples of 125 cigarettes from Brand 1 and 180 cigarettes from Brand 2. The average nicotine content in the sample of Brand 1 was 24.6 mg with a population standard deviation of 1.4 mg; the average nicotine content in the sample of Brand 2 was 24.3 mg with a population standard deviation of 1.1 mg.
- Is there evidence to refute the manufacturer's claim at  $\alpha = 0.05$ ?
  - Construct an 85% confidence interval for the true mean difference in nicotine content between Brand 1 and Brand 2.
8. A team of organizational behavior managers investigated the effects of an orientation program on "first day of work" anxiety levels of new employees. 72 new employees were randomly assigned to receive or not to receive a two-day company orientation program prior to their first day at work. Two hours after beginning work, each employee was given a test to measure his or her level of anxiety. The mean score was 1002 for the 37 receiving orientation and 1018 for the 35 who did not receive the orientation. Scores of employees who attended similar orientation programs in the past have had a standard deviation of 142. Scores of employees that did not attend the orientation program had this same standard deviation.
- Test to see if there is evidence of a difference in the mean test scores between those who participate in an orientation program and those who do not. Use a level of significance equal to 0.05.
  - Calculate the observed significance level ( $P$ -value) of this test.
9. A property manager of thousands of apartments wants to test the difference in the mean net annual income between two types of leasing arrangements. Arrangement A is to charge a lower rent but to require the tenants to make repairs. Arrangement B is to charge a higher rent and to state that the landlord will make the repairs. A sample of 25 apartments using Arrangement A had a mean net annual income of \$1532.50 with a standard deviation of \$400. A sample of 22 apartments using Arrangement B had a mean net annual income of \$1489.20 with a standard deviation of \$100. Test at  $\alpha = 0.025$  that Arrangement B will have a lower mean net annual income by **at least \$10** than Arrangement A. Assume that the incomes are normally distributed and that the population variances are equal.
10. For a consumer product, the mean dollar sales per retail outlet last year in a sample of 25 stores were \$3425 with a standard deviation of \$400. For a second product, the mean dollar sales per outlet in a sample of 16 stores were \$3250 with a standard deviation of \$175. The sales amounts per outlet are assumed to be approximately normally distributed for both products. Test to see if the first product has a better mean dollar sales record than the second product. Use the  $P$ -value approach and base your decision on a significance level of 0.01. Assume that the population variances are not equal.
11. A random sample of 10 filled sports drink bottles is taken in one bottling plant, and the mean weight of the bottles is found to be 22 ounces with a variance of 0.09 ounces squared. At another plant, 10 randomly selected bottles have a mean weight of 21 ounces with a variance of 0.04 ounces squared. Assuming the weights in both populations are normally distributed and the population variances are equal, test whether there is a difference between the average weights of the bottles being filled at the two plants. Use  $\alpha = 0.05$ .

12. Employers implementing workplace wellness programs report reduced healthcare costs, mostly because of fitness center memberships and free preventative screenings for their employees, according to the findings of a survey. Survey results show that employers who invest in wellness programs see increased employee retention, attendance, and productivity. The numbers show that medical costs improve and absenteeism costs improve. The following data have been summarized from the 30 employers that implemented wellness programs in 2011 along with their costs in 2010. The standard deviation of the difference in cost between the two years is \$1322. Assume that independent, random samples were used in the study.

Average Healthcare Cost per Employee (Dollars)		
	2010	2011
Mean	\$11,151	\$10,344
Sample Size	30	30

- Calculate and interpret a 95% confidence interval for the true average difference in healthcare costs between 2010 and 2011.
  - Using the rejection region approach, test that there is a significant decrease in average healthcare costs between 2010 and 2011. Make your decision based on a significance level of 0.05.
  - Calculate the  $P$ -value for the test conducted in part **b**.
13. Travelers are increasingly using tablets and e-readers on planes, trains and buses instead of more basic electronic devices such as cell phones and iPods. According to a study, the use of tablets and e-readers such as iPads, Kindles and Nooks rose more than 50% in 2011 across all modes of transportation. A team of researchers observed 7781 passengers on various airplane, bus and train departures in December of 2011. Their findings were compared with data about technology use among travelers for the fourth quarters of 2009 and 2010. The following table represents the number of travelers surveyed that used tablets or e-readers.

Travelers That Used Tablets or e-Readers			
	2009	2010	2011
Number of Travelers	7545	7185	7781
Number using Tablets or e-Readers	330	570	792

- Perform a hypothesis test using a significance level of 0.05 to determine if there is sufficient evidence to refute the claim that at least 10% of travelers used tablets or e-readers in each of the years surveyed.
  - Calculate and interpret a 95% confidence interval for the difference in the percentage of travelers using tablets or e-readers for 2010 and 2011.
  - Test that the proportion of travelers using tablets or e-readers has increased from 2010 to 2011. Make your decision based on a significance level of 0.05.
14. The University of Michigan Transportation Research Institute believes that a teenage rite of passage may be losing its allure among young people. They believe that teens are in no hurry to get their driver's licenses. In a national study conducted in 1983 with a sample of 10,000 16-year-olds in the U.S., 46% had their licenses. In a similar study in 2008, surveying a sample of 10,000 16-year-olds in the U.S., only 31% had their licenses. Using the information provided, test to determine if there is a significant difference between the proportion of 16-year-olds that had their licenses in 1983 and 2008. Use a significance level of 0.05.

15. The results of a recent study show that people blessed with intelligence are not necessarily free from financial woes. Research by an economist at Ohio State University's Center for Human Research, detailed in an upcoming issue of the journal *Intelligence*, indicated that the smart may still suffer monetarily, making their own financial lives difficult by doing things like maxing out their credit cards and missing bill payments. While past studies have shown a link between being smarter and earning more money, that doesn't mean that those who are intelligent and wealthy don't suffer from debt. Generally, respondents with higher IQ scores earn higher income, with each additional IQ point adding \$202 to \$616 in income annually. However, the study demonstrated that there was no link between total wealth and a person's IQ. With research showing that individuals with higher IQs are not significantly better off financially than those with average or below average intelligence, the suggestion is that those who are smarter may not be as good about saving money as others. In fact, the researchers discovered that more intelligent people were actually slightly more prone to financial problems, with more than 12 percent of those with an IQ of 90 having maxed out their credit cards, versus less than 8 percent of those individuals with an IQ of 75 and below. Among the highly intelligent, or those respondents with an IQ greater than 125, 6 percent had maxed out credit cards and 11 percent occasionally missed payments. Additionally, there appeared to be a financial sweet spot near the average IQ score, for which individuals had the lowest financial distress. The survey looked at information provided by 7400 respondents who took part in the National Longitudinal Survey of Youth, which considered baby boomers nationwide. The latest study is based on data from 2004, when participants were 40 to 47 years old. Respondents were polled about income and total wealth, as well as three measures of financial distress: whether they had maxed out credit cards, if they missed paying bills during the past five years, and if they had ever declared bankruptcy. The Armed Forces Qualification Test, long used to measure intelligence, was used to generate IQ scores. As a takeaway, the study's author, economist Jay Zagorsky, stated that people with lower intelligence should not feel like they are at a financial disadvantage, while those people with a high IQ should not feel they are at an advantage. In other words, every person has the ability to make smart financial decisions like avoiding debt, regardless of his or her intelligence or income. The following table contains some of the data from the study.

Income and Intelligence				
IQ	Average Income (\$)	Average Total Wealth (\$)	<i>n</i>	Percentage with Maxed out Credit Cards
<75	55,000	500,000	2000	7.8
90	70,000	750,000	3000	12.0
>125	95,000	950,000	2400	6.0

Source: "Smarter doesn't mean richer," May 14, 2007, [www.creditcards.com](http://www.creditcards.com)

- Determine if there is a significant difference in the proportion with maxed out credit cards of those with an IQ of 90 versus those with an IQ less than 75. Make your decision based on a significance level of 0.05.
- Calculate a 95% confidence interval for the difference in the percentage of people with maxed out credit cards between those with an IQ of 90 and those with an IQ more than 125. Interpret the interval.
- Did you make any assumptions to carry out the test in **a.** or to calculate the confidence interval in **b.**? If so, what were they?

16. A company believes that the variance in revenue from products produced in two facilities, measured in millions of dollars, is greater for Facility A than for Facility B. The sample standard deviation of a random sample of 19 products from Facility A is 1.5984 million of dollars. The sample standard deviation for a random sample of 18 products from Facility B is 1.0426 million of dollars. Assume that both population distributions are approximately normal and test the company's claim using a 0.10 level of significance. Does the evidence support the company's claim? Let the products produced in Facility A be Population 1 and let the products produced in Facility B be Population 2.
17. Shirley is analyzing her family's budget regarding how much they spend when eating out. She believes that the variance in expenditures when eating out is less when she uses cash as compared to when she uses her credit card. The following data represent a random sample of her family's cash and credit card purchases when eating out last month. Assume that both population distributions are approximately normal and test Shirley's claim using a 0.05 level of significance. Let Population 1 be the cash purchases and let Population 2 be the credit card purchases.

<b>Cash</b>	\$24.24	\$26.96	\$22.48	\$26.45	\$26.74	\$23.99	\$25.70	\$26.73	\$25.12	\$24.23
<b>Credit Card</b>	\$20.46	\$25.02	\$26.36	\$23.95	\$25.84	\$24.96	\$20.82	\$23.41	\$24.70	\$23.58